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About Authors

● **A. T. Colwell** *(M '30), is credited with much of the successful research and development work done on improved heat-resistant valves and valve-seat inserts, especially for high-duty automobile and aircraft engines. He graduated from West Point as a distinguished cadet in 1918 and spent four years in the Army, during which time he received his C.E. degree from the Engineering School at Fort Humphreys, Va. He then joined the Steel Products Co., which later became Thompson Products, Inc., as junior salesman. He has remained with the company, advancing to sales engineer, director of engineering, and, in 1937, to vice-president in charge of engineering. He is serving his second year on the SAE Council, and in 1936 was chairman of the Cleveland Section. He has also been active on several of the Society's technical and administrative committees. An excellent golfer, Mr. Colwell won the SAE championship in 1936 and was runner-up in the 1938 tournament held during the Summer Meeting.*

● **Graham Edgar** *(M '30) received his degree of B.S. from the University of Kentucky in 1907, and the degree of Ph.D. from Yale University in 1909. He was professor of chemistry for a number of years at the University of Virginia, and joined the Ethyl Gasoline Corp. in 1924 as director of research. He was made vice-president of the company in 1932.*

● **A. H. R. Fedden** *(FM '27) has been selected Guggenheim Medalist for 1938 "for contributions to the development of aircraft-engine design and for the specific design of the sleeve-valve engine." He holds the Society's Manly Memorial Medal for 1933, is president of the Royal Aeronautical Society and is an Honorary Fellow of the Institute of the Aeronautical Sciences. He was awarded the M.B.E. for his war work in supervising the manufacture of Rolls-Royce and Renault airplane engines and the re-design and overhaul of a large number of Curtiss liquid-cooled engines. During the latter part of the war he began the development of the "Jupiter" engine, and, when the Bristol Aeroplane Co. took*

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Publication Office, 56th and Chestnut Sts., Philadelphia, Pa.; Editorial and Advertising Departments at the headquarters of the Society, 29 West 39th St., New York, N. Y. Western Advertising Office, Room 2-136 General Motors Bldg., Detroit, Mich.

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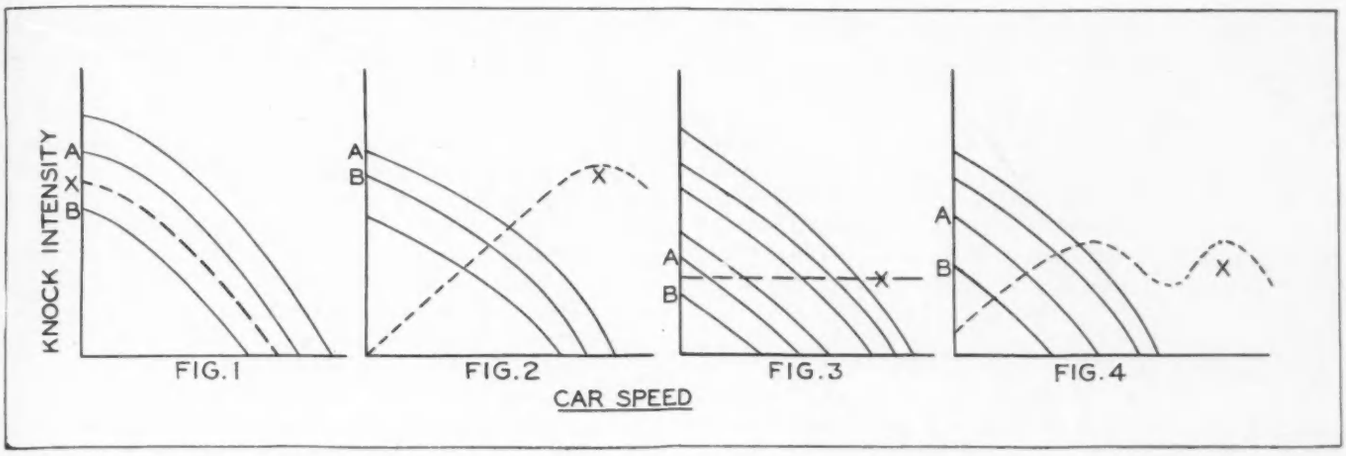


The knocking tendency of test fuels and reference fuels is not always affected in the same way by the same variations in car operation – as is shown by these four typical examples.

Knock-Testing –

In the Laboratory and in Service

By Graham Edgar

Director of Research and Vice-President, Ethyl Gasoline Corp.

THE problem of knock-testing, both in the laboratory and in service, is one of extraordinary complexity. Some phases of the problem are obvious, others obscure, and it has seemed to the writer desirable to present a partial analysis of the problem, citing many of the factors involved and indicating some of the limitations which are inherent to the problem of correlation of laboratory methods with service conditions. Since the problem as applied to the airplane is quite different from the problem of the automobile, these two subjects have been considered separately, although many of the general principles employed are applicable in either case.

Part I – The Automobile

Knock-Testing in Cars on the Road

1. Since the behavior of a fuel in actual service ultimately will determine its value irrespective of laboratory tests, it seems desirable to consider first the knocking characteristics of fuels in actual automobiles.

In the first place, it may be pointed out that knocking as usually encountered in passenger automobiles is seldom sufficient in itself to affect the *performance* of the automobile to an extent which can be measured readily. The *sound* of the knock is objectionable to the driver (the extent of the objection varying greatly with the individual), who, therefore, usually considers a fuel as "satisfactory" from an antiknock standpoint when it knocks infrequently or very lightly in his own automobile. A road knock test of a fuel is therefore unique in that it represents an attempt to evaluate a psychological factor (the driver's objection to the sound of the knock), and not some property capable of direct measurement.

AN exact correlation between laboratory methods of knock-testing and service results is hardly to be expected on theoretical grounds, believes Dr. Edgar. And the problem of "average road knock-ratings" calls loudly for statistical study, he contends, pointing out that no really sound statistical basis has been worked out.

Because of the extraordinary complexity of the problem both in the laboratory and in service, he shows that much uncertainty attends the interpretation of any individual service knock test.

The paper discusses the problem broadly, attempting to point out what is possible to achieve in the solution of the problem and what is not possible.

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 16, 1938.]

2. Knock Tests of a Fuel in a Single Car – Whether or not a given fuel will cause knock in a given car depends upon (a) the inherent tendency of the fuel to knock; (b) the inherent characteristics of the particular car (for example, compression ratio, volumetric efficiency, spark advance, manifold design, carbon accumulation, and so on, and (c) the conditions under which the car is operated (for example, throttle opening, grade of the road, speed, atmospheric temperature, humidity, barometric pressure, and so on). In order to measure (a) it is clearly necessary to eliminate or control (b) and (c) as far as may be possible. This purpose is effected partially by making the knock test a *comparison* of the fuel under test with some other fuel or fuels whose behavior is known under a wide variety of conditions on the road and in the laboratory, and whose inherent tendency to knock is close to that of the fuel under test. Such fuels are called "reference fuels," and a series of them differing from each other in knocking tendency by small increments must be available in order to carry out a road knock test on any fuel. Further control of the non-fuel variables is effected by standardizing, as far as is practicable, the conditions under which the test is run. Since knocking is normally greatest at full-throttle operation and may occur over a wide speed range, the present standardized road knock tests consist, briefly, of accelerating the particular car on the particular fuel under test at full throttle in high gear, beginning at a speed of about 10 m.p.h. and continuing over the entire speed range in which knock is observed. Knock intensity by ear is recorded at different speeds. The operation is then repeated with two or more "reference fuels" until one of these is found which gives approximately the *same maximum knock intensity* as that of the fuel under test. The knock rating of the unknown fuel is then said to be equal to that of the reference fuel giving equal maximum knock intensity.

Test Factors

Let us consider, briefly, some of the factors involved in such a test:

In the first place, experience has shown that the knocking tendency of two different fuels (for example, the test fuel and the reference fuel) not always is affected in the same way by the same variations in car operation. Thus, if one plots knock intensity (measured as just indicated) against car speed, one may find in a given car results of the type illustrated in Figs. 1, 2, 3, and 4.

If we consider Fig. 1, it is clear that the unknown fuel *X* falls between the known reference fuels *A* and *B* and, if these fuels have laboratory octane numbers of 68 and 70 respectively, *X* may be said to have a road octane number of 69. The case is quite different, however, with fuels showing the behavior illustrated in Figs. 2, 3, and 4. The variation of knock intensity with speed is so different for the reference fuels and the unknown that no more sound technical comparison may be made of them than that which may be made between cheese and ice cream. Accepted practice is to assume that some certain level of knock intensity is probably objectionable to each individual driver, and that he probably rates fuels as unsatisfactory or satisfactory according to whether or not this particular knock intensity is reached irrespective of the speed at which it is reached. Accordingly accepted practice rates as equal an unknown fuel and a reference fuel having equal maximum knock intensity. Thus, in Figs. 1, 2, 3, and 4, the fuel *X* is rated always as between reference fuels *A* and *B*. This is probably as good a compromise as can be made, but it leads to certain uncertainties. Thus, in Fig. 2, *X* is undoubtedly better than reference fuel *B* at low car speeds, and the driver who experiences knock mostly at low speeds would not agree with the official rating given. Conversely, the driver who experiences knock mostly at high speeds would reverse this rating. Also, considering Fig. 3, few drivers would rate fuel *X* as better than fuel *A*, since a light knock persisting over a wide speed range certainly would be more objectionable than one occurring only over a short range.

Furthermore, except in quite hot weather, the results of a knock test made as just outlined may not correspond closely to those found if the car is decelerated at full throttle on a steep hill, and the "official" rating may not agree with the experience of the driver under these conditions.

A much more important complication arises from the fact that the relative knocking tendency of the reference fuels and fuel *X* may vary in this test with barometric pressure, atmospheric humidity, and especially with atmospheric temperature, the latter effect being frequently profound. The effect of barometric pressure is not well known; the effect of humidity is probably not more than two or three octane numbers maximum, but the ratings of fuel *X* in hot and cold weather may differ by as much as *eight* octane numbers.

Altogether, it is fair to say that even the simple case of the determination of the road antiknock value of a fuel in a single car can at best only hope to reflect the impressions of the average driver, and may not agree with the impressions of any individual driver. Furthermore, such an antiknock value can hold only for the conditions under which the test was run.

3. Average Road Knock-Ratings – Although individual fuel ratings in an individual car perhaps may be important to the driver of that car, the manufacturer of gasoline must know the behavior of his fuel, as far as possible, in all cars. Hence, the "Average Road Knock-Rating" is of the utmost importance.

The average road knock-rating obviously is made up of a large number of individual road knock-ratings and, thus, is subject to the same uncertainties of interpretation and result as are the individual ratings. In addition, there are some problems involved in the "average" figures which are not easy to solve.

In the first place, experience has shown that individual knock-ratings of a given fuel *X* may vary considerably when determined in different cars of the same make, model, and year, and under substantially comparable atmospheric conditions. Thus the extreme variation found by the Bureau of Standards for the rating of a certain fuel in 24 cars of a certain make was *four* octane numbers. For a number of cars in the hands of different operators the 1937 C.F.R. tests showed that individual ratings of the same fuel on cars of the same make, model, and year may show a variation of as high as *ten* octane numbers.

Furthermore, the rating of fuel *X* in cars of different makes, or in the same make for different years, may vary by very large amounts. Thus, in the C.F.R. tests at Uniontown in 1932, under comparable atmospheric conditions, individual ratings of the same fuel in two different cars differed by as much as *twelve* octane numbers, and variation of this order has been experienced in all cooperative tests since that time.

Neglecting the influence of barometric pressure (altitude) and of humidity as yet not well enough known, the influence of atmospheric temperature on road knock-ratings has been shown to be of major importance. Individual ratings made in cold and hot weather may differ in some cars by as much as *eight* octane numbers, and this condition is also true of *average* ratings, although the effect of temperature is not the same for every car.

Clearly the problem of "average road knock-ratings" calls loudly for statistical study, and yet no really sound statistical basis has been worked out – partly for lack of data, and partly for lack of agreement as to the proper method of statistical treatment.

Theoretically, in order to have a true "average road knock-rating" for our unknown fuel *X*, it would be necessary to have: 1. individual road knock-ratings taken on enough individual cars of a given make, model, and year to average out the individual idiosyncrasies just mentioned; 2. the data under 1. repeated for cars of every make, model, and year which appear to be of interest; 3. the data under 1. and 2. taken under a sufficient variety of atmospheric conditions to determine the effect of these factors on the ratings for each make, model, and year.

If all of the above data were available for our fuel *X*, it would be possible to assign to it an "average road knock-rating," or rather any one of a series of such ratings dependent upon the statistical method employed in the averaging. Thus, a straight arithmetical average of all data would not give the same results as would be obtained by weighting the different cars in proportion to some function of their numbers on the road, and arguments could be produced for several different systems of weighting. Also the data under different temperature conditions, in many cases, would not be directly comparable, and must either be averaged (weighted or not), or several different average ratings made to correspond to different climatic conditions.

However, out of all the welter of data concerning fuel *X*, some fair "average road knock-rating" *could* be agreed upon, but it is probable that by the time all the data had been accumulated, and by the time some system of evaluating them had been agreed upon, fuel *X* would no longer be on the market and most of the cars upon which its rating was based would have been scrapped!

Because of the utter impracticability of obtaining "average road ratings" which are really adequate to avoid all uncertainty of fact (uncertainty of interpretation can *never* be avoided), those agencies, committees, or companies which have attempted the problem of average road ratings usually have followed the well-tried course of "doing the best one can on an impossible task."

The procedure which was followed at Uniontown in 1932 and 1934 by the C.F.R. Committee, and by various individual companies has involved substantially the following: 1. obtain as many individual cars of the current year as is practicable (usually a total of 12 to 20), seeing to it that all important makes are represented; 2. select a group of fuels of different chemical types and different antiknock values; 3. rate each fuel on as many of these cars as is practicable; (see further discussion following); 4. assign "average road knock-ratings" which are the arithmetical average of all ratings taken under similar conditions; 5. assume or hope that the results will hold reasonably well for other cars and for other fuels than those tested. In some cases a partial attempt at weighting the car results has been made by using more of the cheaper cars than the more expensive ones. In no case has the number of cars been really adequate, and only recently have the important matters of atmospheric conditions and spark setting been given consideration.

In even so limited a program as that just indicated, certain problems arise which throw uncertainty on the results. For example:

1. Where only one car of a given make is tested it is always possible that the ratings on this particular car do not reflect accurately the average ratings for the particular make and year.

2. The knock-intensity range in which satisfactory road knock-ratings can be made is rather limited. Thus, if a fuel does not knock at all in a given car, no rating can be made for that fuel in that car without altering somewhat the characteristics of the latter to induce knock. Similarly, if a fuel knocks too heavily in a given car, no satisfactory ratings can be obtained without altering the car to reduce knock. Altering the spark advance usually is resorted to to increase or decrease the knock and permit a wider range of fuel to be tested in a given car, but it is known that, in many cases, alteration of spark advance alters the knock-rating. For these reasons, either all fuels will not be rated in all cars (so that the averages will not be comparable), or the fuels will be rated at different spark advances, thus throwing doubt on the results. There appears to be no escape from this dilemma.

4. The sensitivity of the car to changes in the antiknock value of the fuel appears to vary from car to car, and for the same car with atmospheric conditions. This condition complicates the problem of evaluation of the data in terms of actual car behavior.

5. Unless all tests are run under substantially the same conditions of atmospheric temperature and humidity, the results may not be closely comparable, whereas, if they *are* all run under comparable conditions, the results may apply only to those conditions.

Accordingly, every experimental program of the past designed to give "average road knock-ratings" has been subject to very definite uncertainties and, although the values obtained for the fuels under test can be (and have been) attacked very easily on one ground or another, it appears certain that this situation will also be true of any future test program.

Testing of this kind is so expensive, laborious, and time-consuming that it is improbable that really adequate data will ever be obtained. However, the probabilities are that the data usually will give a reasonably satisfactory basis for the development of laboratory methods of knock-testing which shall not be too far off in reflecting the "average driver's" reaction to fuel performance in the "average car" under "average conditions." *It should always be remembered, however, that these average ratings enable us to predict little about the behavior of an individual fuel in an individual car and, conversely, that an individual road test tells little or nothing about average figures.*

Laboratory Knock-Testing

The problems of laboratory knock-testing, in many cases, are very different from those involved in road knock-testing. It must be remembered that all laboratory tests are primarily designed for the *purpose of maintaining the specifications on the basis of which products are manufactured and sold,* and this purpose is definitely true of knock-testing. In a car on the road we are trying to find out how the relative behavior of two fuels would be interpreted by the "average driver." In the laboratory we are attempting to determine whether or not a sample meets some particular specification for "octane number." In both tests we make a *comparison* of the unknown fuel with known reference fuels, but there the similarity ends. The laboratory test must be so standardized and controlled that the highest precision and reproducibility possible must be attained. The maintenance of specifications represents a large cost item, and variations in antiknock value of a small fraction of an octane number (completely unimportant in any single test in a car on the road) may represent millions of dollars of cost when multiplied by billions of gallons of production.

Since, however, there is little use for a specification which

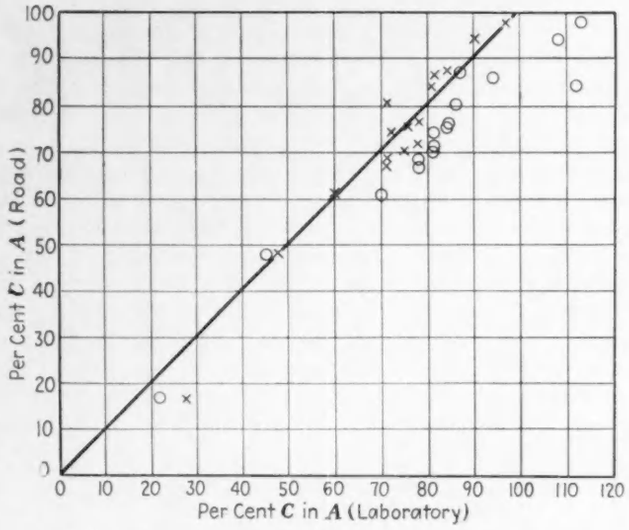


Fig. 5 – Correlation of Road and Laboratory Results

does not bear some relation to the usefulness of the product, the laboratory test must be expected to give results which reflect, as well as may be practicable, the performance of the product in service. *The laboratory knock test of gasoline therefore must be expected to give results which bear as close a relation to average road performance as it may be practicable to attain.*

Correlation of Laboratory and Road Testing

As far as the writer has been able to determine, all laboratory knock-testing procedures developed prior to 1932 were developed without reference to the behavior of fuels on the road. The various engines and procedures employed had been developed, apparently, purely in the interest of reproducibility and precision, and without an experimental background of road data from which to draw conclusions.

In 1932, the Ethyl Gasoline Corp. made some extensive road tests which indicated that serious discrepancies existed between the results of the then-used laboratory methods and the results of road tests, and shortly thereafter the C.F.R. Committee carried out the first series of Uniontown tests. The standardized road knock test procedure (2. under "Knock-Testing in Cars on the Road") was developed and applied to a program of the type just described (3. under same heading). Arithmetical averages of all tests were taken and, as a result, "average road knock-ratings" in terms of conventional reference fuels were assigned to some 14 typical fuels. Laboratory tests were then made under a variety of conditions and finally a method was devised, known as the C.F.R. Motor Method, which gave reasonable correlation with the road results. It may be pointed out that the road results were subject to criticism on many of the counts just discussed, but they represented a far more substantial mass of data than had been previously available, and the general acceptance of them and of the Motor Method was warranted in every way.

In 1934, similar tests carried out by the C.F.R. Committee indicated that the Motor Method still gave substantial agreement with the overall average figures, though there were unmistakable indications of divergencies from proper correlation in the case of certain fuels.

In 1936, the Ethyl Gasoline Corp. carried out extensive tests under varying temperature conditions and brought out the effects of atmospheric temperature on road knock-ratings in cars of recent manufacture. This finding has complicated the whole problem of correlation of laboratory ratings and road ratings, both from the standpoint of the technical problems involved and from the standpoint of the fair evaluation of the data, for the latter consideration involves inevitably problems of statistical methods about which many arguments may be raised, and which cannot always be answered categorically.

The writer proposes in the following to attempt to analyze the correlation problem and to show some of the factors which must be reckoned with in future studies of the subject. Heretofore, he has confined himself entirely to matters of fact – what follows below contains inevitably many matters of personal judgment. The writer would be surprised and disappointed to find a large proportion of his readers agreeing with a majority of his conclusions.

We start with a series of "average road knock-ratings" expressed in terms of certain reference fuels. The problem is the development of a laboratory test method duplicating these ratings as far as may be possible which, at the same time, has high precision, reproducibility, and reasonable simplicity. Let us consider first, as it is much the simplest case, a series of road data taken under comparable atmospheric conditions and at fairly high temperature.

It is helpful to express the data graphically. Thus, if we plot as ordinates the average road ratings, expressed in percentages of the two reference fuels, and plot as abscissae the laboratory ratings expressed similarly, it is clear that perfect correlation of laboratory and road results must be represented by a 45-deg. line passing through the origin, and the deviation of the experimental results from such a line expresses the extent by which the laboratory method fails to give perfect correlation.

Such a plot is shown in Fig. 5. The circles represent road data obtained at Uniontown in 1934, plotted against ratings by the Research Method; the crosses represent the same data plotted against the Motor Method.

It is clear from inspection of the data that the crosses scatter fairly well around the line of perfect correlation, whereas the circles show a definite trend away from the line. Correlation with the Motor Method is thus much better than with the Research Method, although the deviation from the Motor Method ratings by some fuels is greater than could be desired. It is probable that slight modifications of the Method could have improved the correlation somewhat, but a change in laboratory method, in general, is justified only when a substantial improvement is effected.

It may be emphasized at this point that there is no theoretical reason why any laboratory method can be expected to agree perfectly with any group of average road ratings; in fact, every theoretical reason suggests that such agreement must be largely fortuitous. The elements essential to a laboratory test – exact control of conditions – are foreign to the very nature of the road tests; moreover, when we recall the variation of the road results among different cars, it seems most unlikely that any single laboratory test can agree well with "average" tests of a variety of fuels. We do not know today all of the factors that influence the road ratings of fuels, but we do know that they are influenced by fuel-air ratio, spark advance, cylinder-head design, speed, and so on, and we also know that several of these vary *continuously* while a road test is being made. Under many conditions of atmospheric temperature, the distribution of the fuel charge in a multicylinder engine is far from perfect, the air-fuel ratio in the different cylinders varying quite substantially. Furthermore, during the accelerating period when knocking is most apt to occur, the fuel charge from the carburetor is only partially vaporized in the manifold, and the actual chemical composition of the fuel being burned in the individual cylinders is

not the same as the overall fuel being fed from the carburetor. The laboratory engine (in any form as yet developed) must run under static conditions, and it is certainly not to be expected that its ratings can be so modified by conditions of operation that they will agree exactly with average road ratings taken necessarily under such widely differing conditions.

The writer does not think it likely, therefore, that any better agreement with any single set of "average road ratings" is apt to be possible in the future than was achieved in 1932, but it does appear likely that some method (or combination of methods) can be found which will agree about as well as has been true in the past with any single set of road ratings, provided the range of fuel types and of octane numbers considered is not too wide.

As pointed out previously, however, the discovery of the effect of atmospheric conditions on road ratings makes it appear possible that in the future we always shall be confronted not with a single set of "average road ratings" but with several sets of ratings under different atmospheric conditions. Any proper solution of this problem involves many factors, and many of these factors involve matters of opinion and cannot be settled on the basis of technical facts alone.

In 1937 the petroleum and automotive industries carried out the most extensive cooperative program of road and laboratory tests which has yet been attempted. The results of these tests have been analyzed more carefully than has ever been done before. Experienced and capable engineers have burned the midnight oil while preparing charts and tables. Three-dimensional models have been prepared in an attempt to visualize the behavior of different fuels under different methods of test. And yet, with all of it, no simple solution of the correlation problem has been found. The writer has not participated in this particular statistical analysis, and therefore feels free to discuss in detail some of the general statistical problems which are involved, indicating the ideal solution (where one exists), but also recognizing that the ideal solution from the technical standpoint frequently runs foul of objections (occasionally well-grounded) from the practical aspects of petroleum marketing, and that compromise is eventually necessary. There is nothing to be gained, however, by approaching the technical problem with the blind assurance that the simplest, easiest, and most profitable solution of the problem is necessarily the right one.

The first step in the analysis of the data is to obtain for each fuel a "road rating" for each make of car. In the case of the 1936 cars, as indicated previously, tests of the same cars under different atmospheric conditions showed a definite trend of the ratings with atmospheric temperature. An obvious step, therefore, is to plot the 1937 ratings for each individual make of car against atmospheric temperature. One of several things may result:

a. We may find a definite trend with temperature. In this case we are faced with the problem of 1. collecting the data into different temperature brackets and averaging them to determine a series of road ratings under different average temperature conditions; 2. weighting the data in accordance with some scheme of evaluating the relative commercial importance of knocking at different temperatures, and thus arriving at some single weighted average rating.

Many arguments may be raised as to the best method of handling this situation, and time does not permit its further discussion.

b. The data may be consistent with each other but show no trend with temperature.

In this case obviously a simple average of the results gives a satisfactory rating.

c. The data may be so scattered as to make any exact determination of trends impossible.

Here again, a grand average of all ratings is the best that can be obtained but, in making such an average, it must be borne in mind that individual cars may vary widely from the average.

For the 1937 results, the writer has plotted the data for one or two individual fuels against the temperature, and the results might be called a "shotgun pattern" although to do so is an insult to any self-respecting maker of arms or ammunition! Experience has shown that this result is apt to occur when a large mass of data taken by different operators and in different individual cars is treated. The number of factors which may affect the ratings is so large that individual trends are apt to be lost. The most satisfactory method of obtaining the effect of temperature or any individual factor on road ratings is to use the data of one laboratory (or a cooperating group) using identical cars and observers. In the absence of such data (and they are absent for the 1937 cars), about all that can be done is to take an arithmetical average of the data for a given make of car, and use that for further averaging with the results on other makes of car. This procedure does not mean that the effect of temperature is absent, but merely that the data do not permit its evaluation.

When these same steps have been taken for every fuel and every make of car, we are then able to give consideration to the "grand average rating" of the fuel in question.

Questions Weighed

Certain questions arise at once, for example:

1. How shall the car ratings be weighted?

It would appear that the car ratings should be weighted according to the approximate ratio which the sales volume of each car make bears to the total sales volume. It has been suggested that the higher-priced cars should be given somewhat more weight than their production justifies because of the fact that their drivers are probably more particular about knock than are drivers of cheaper cars. This principle seems too vague to consider.

2. Shall all data be included in the average, or shall data at normal spark advance be given extra weight, or shall data at average temperatures be given extra weight?

It is not the purpose of the writer to express an opinion as to the answer to these questions, but merely to point out that they arise and must be answered. In any case, whether weighted or not, a set of average road ratings finally must be agreed upon, and these ratings will be the "official" road ratings of 1937 in 1937 cars. (It may be noted here that the truck, bus, and tractor have been omitted from consideration, and there are good reasons for believing that the road rating of fuels for heavy-duty equipment will vary considerably from passenger-car ratings.)

The next problem concerns the relation of these data to present and future laboratory methods of test. The first step in this problem, of course, will be to determine how well the grand average data agree with existing methods of test (A.S.T.M., L-3, and so on). The indications are that the data do not agree well with any existing method. We are then faced with the broad problem of developing a method or methods to correlate as well as may be possible with the road results.

Certain problems arise at once which must be decided before any progress can be made.

3. Shall the laboratory method be based on 1937 cars alone and, if not, how shall data on older cars be weighted?

In the first Uniontown tests in 1932, the data were obtained essentially on 1932 cars, with a few scattering data on

1931 cars which indicated, as far as it went, substantial agreement with the 1932 data. The second Uniontown tests were carried out on 1934 cars. No further cooperative work has been carried out, but available data on 1936 cars indicated quite definitely that the results obtained on these cars in cold weather (at least) deviated substantially from those obtained with earlier models. When the 1937 data finally are obtained, there will be no substantially equivalent data for earlier models. For this reason, it would appear that any revision of a laboratory test must be based on the 1937 cars alone. In the future it is perhaps possible that adequate data will be obtained for the models of each year and, if so, the writer believes that laboratory methods should probably be based on the data for three years, weighting the current models 50 per cent, the previous year 30 per cent, and the third year 20 per cent. The reason for neglecting the cars older than three years is that trends of automotive design and fuel manufacture are such that the older cars are apt to be less critical in their antiknock requirements and, therefore, any deviation of laboratory ratings from road ratings is less important. The reason for weighting the current model highest is that the new car undoubtedly averages higher mileage (and thus greater gasoline consumption) than older cars, and also that the driver of a new car is apt to be more critical of the fuel than the driver of an older car. Weighting of this kind, of course, is open to much argument.

4. Shall a single method be developed, or shall ratings made under different conditions be employed, and the final ratings made by computation from these different ratings?

It is perhaps impossible to answer this question purely on a technical basis. Obviously, one laboratory method has the advantage of simplicity and convenience; it has a probable advantage of increased precision; and it lessens the possibilities of deliberate or accidental confusion among sales and advertising agencies where more than one octane number is determined for a fuel.

However, a single laboratory method tells only one thing about a fuel – its antiknock value under one specific method of test. Experience has shown that different fuels react very differently to changes in the conditions of test and, therefore, fuels rated as equal under one condition may vary widely under other conditions, both in the laboratory and on the road. It is the writer's opinion that there is a much better chance of duplicating road ratings in the laboratory by a combination of methods than by any single method.

An ideal procedure would take into account both the effect of temperature and the effect of volatility. To do this it is necessary to develop, say two laboratory methods corresponding to two extremes of temperature, coupled with a correction factor expressing the effect of volatility, and so to perfect these methods that average road ratings can be expressed as

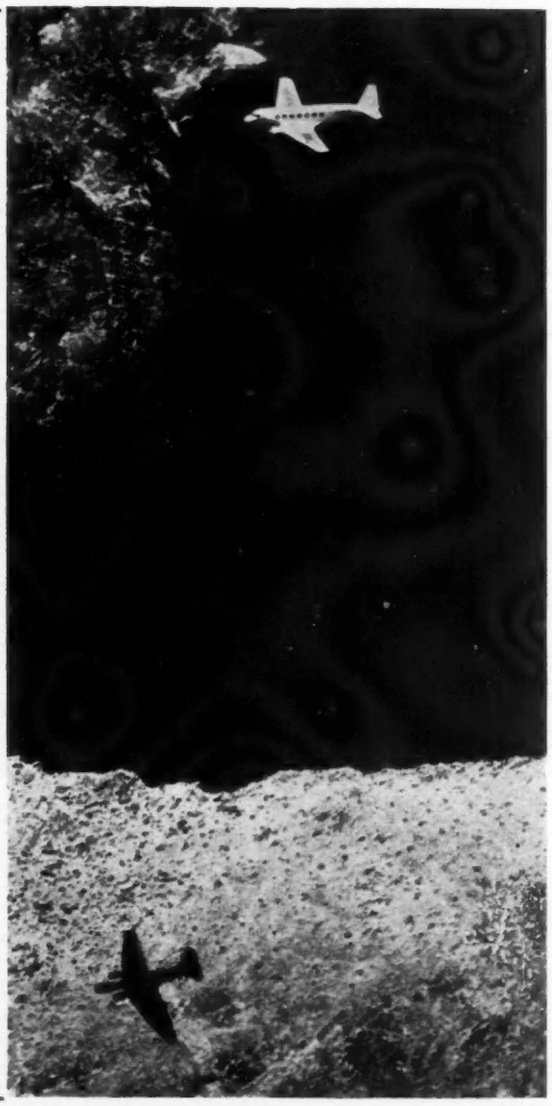
(*Continued on page* 17)

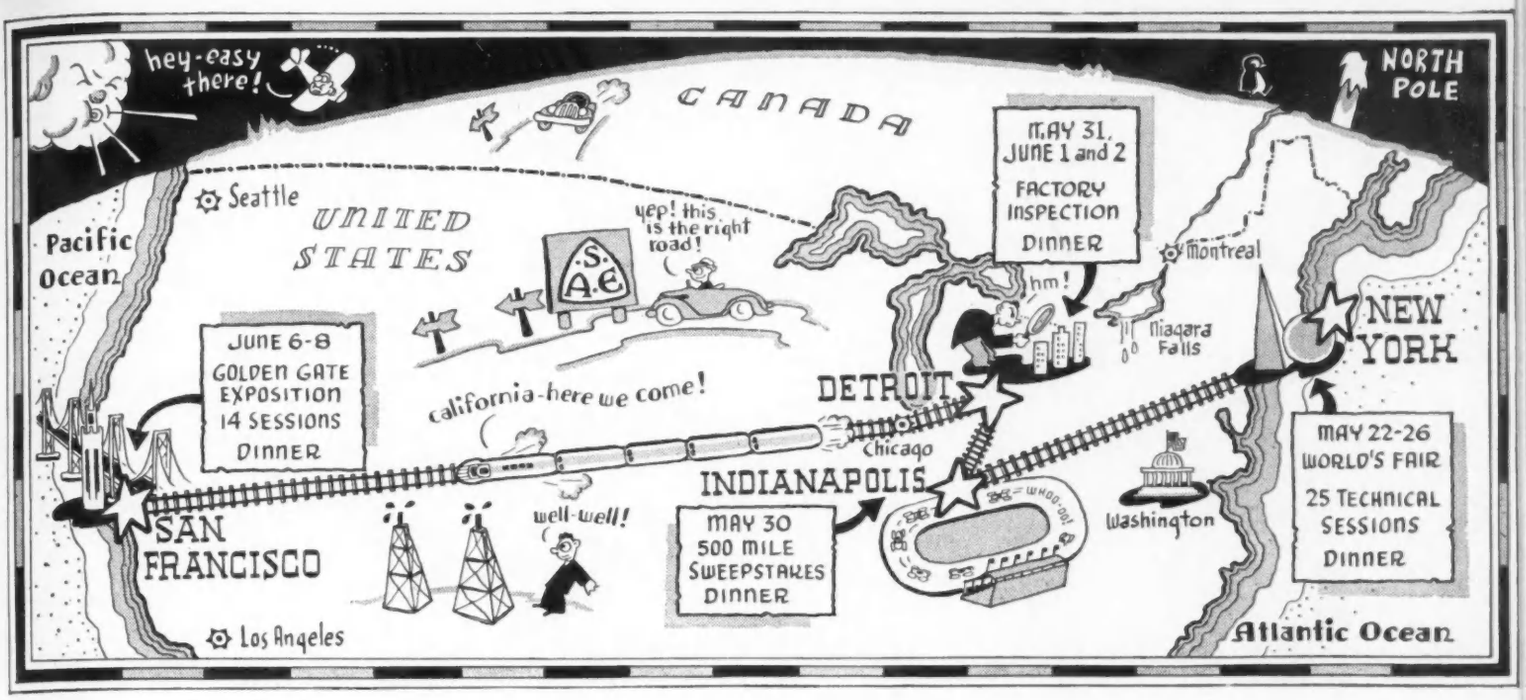
National
Aircraft Production Meeting

OCT. 13-15

LOS ANGELES

Ambassador Hotel





WORLD AUTOMOTIVE ENGINEERING CONGRESS

of the

SOCIETY OF AUTOMOTIVE ENGINEERS, INC.

New York — May 22-26

5 Days of Technical Sessions on all phases of Society activity

Big Congress Dinner on May 25

Time to visit the New York World's Fair

Headquarters—Hotel Pennsylvania

Indianapolis — May 30

Attend the 500 Mile Indianapolis Race

Indiana Section S.A.E. Dinner the night before the Race

An opportunity to visit the "pits" and see the cars the day before the Race

Headquarters—On Air Conditioned Train parked a short distance from the Speedway

1939 MAY 1939

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

1939 JUNE 1939

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Detroit — May 31, June 1-2

3 Days of Inspection Trips through the principal Automotive Plants

Detroit Section S.A.E. Dinner

Headquarters—Statler Hotel

Chicago — June 3

Board a Diesel Streamliner for San Francisco

San Francisco — June 6-8

3 More days of Technical Sessions

A Big West Coast Dinner on the last evening—June 8

An opportunity to visit the Golden Gate's Exposition before returning home

Headquarters—Fairmount Hotel

Technical Papers marking the rapid march of automotive developments throughout the world will cover Aircraft, Aircraft Engines, Diesel Engines, Fuels and Lubricants, Passenger Cars, Bodies, Production, Tractors, Transportation and Maintenance, Trucks and Buses

Many of the prominent Engineering Societies in foreign countries are cooperating in this World Event.

S·A·E Student Branches

GENERAL MOTORS INSTITUTE

Data Supplied by Richard F. Grogan, SAE Student Branch Secretary-Treasurer (Section A) at General Motors Institute

THE SAE Student Branch at General Motors Institute tops all others in membership. It holds the third charter to be granted by the Society. Established in November, 1927, the Branch has grown from an organizing group of thirty to its present membership of more than fifty.

As a part of a school which is closely allied with the automotive industry, the Branch, since its inception, has been one of the most popular Student activities on the campus. Inspection trips to local manufacturing plants and other nearby points of engineering interest, augmented with trips to plants in Detroit, Saginaw, Lansing and Milford, are highspots on the Branch's program; and the annual visit to General Motors Proving Grounds usually proves the season's most popular activity.

Several times each year the Branch meets for dinner and invites prominent men of the industry to discuss various phases of automotive engineering. Members also attend many of the Detroit Section's meetings and the Annual Meeting of the Society as a body.

Under the cooperative engineering training program at G.M.I., students alternate between the school and a General Motors plant every four or eight weeks. Two students are usually employed at the same job, one working while the other attends classes. During the work period students are paid, and in most instances earn enough to cover their tuition and living expenses while at school.

Last year 562 students participated in the cooperative program which includes five departments of instruction – automotive engineering, body engineering, industrial engineering, tool engineering and service engineering. It is a four-year course of college grade, requiring a high school education or its equivalent for entrance. Only third and fourth-year men are eligible for membership in the Student Branch.

Because of the cooperative system the Student Branch is made up of two sections, one active at the school while members of the other are

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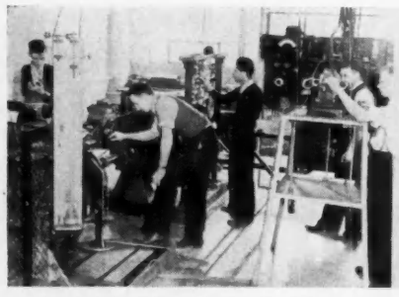
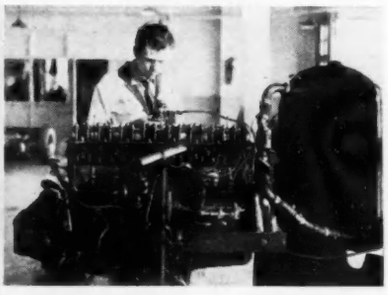




G.M.I. Students get practical experience in the Institute's automotive laboratories.

News of the Society

Looking Ahead at SAE Meetings for 1938-1939

Here's one prediction that cannot miss. . . . SAE meetings will reach a new high in quality during the 1938-1939 season.

The hot months have not kept National and Section officers from "going to town" in their plans for the coming season, culminating with the SAE World Automotive Engineering Congress in the early summer of 1939.

September is still pretty warm in most parts of the country and meetings scheduled for this month are mostly in the nature of outings. Metropolitan Section opens its season Sept. 15 at the Manhasset Bay Yacht Club, Long Island. Leading boat builders will have their products on display at the club anchorage and a side trip is planned to the Pan American Airport at Port Washington where a Bermuda ship may be inspected. This will be followed by a cooling swim, dinner and dance at the club. Milwaukee is planning a golf meeting on the sixteenth. Buffalo also will devote an afternoon to the ancient and royal game. Northern California Section's Sept. 13 meeting will be devoted to aircraft with Pan American's Pacific Division operation engineer, George W. Smith, and Fred W. Herman, assistant to the chief engineer at Douglas, presenting papers.

Officers Visit Coast Sections

Late in the month and early in October President C. W. Spicer and General Manager John A. C. Warner will be guests of honor at meetings of the Oregon, Northwest and Northern California Sections and the SAE Club of Denver on the annual presidential tour. The National officers will make their headquarters in Los Angeles during the National Aircraft Production Meeting, visiting with members of the Southern California Section at that time. The Northwest Section is also scheduling a closed meeting on Sept. 9 at which plans for the coming season will be discussed.

October starts a series of particularly interesting SAE National Meetings. The first will be the T. B. & R. Meeting in Chicago, Oct. 4 & 5 (previewed on page 15), which will be followed by the Fuels & Lubricants Meeting in Tulsa, Oct. 6 & 7; and the third annual Aircraft Production Meeting in Los Angeles, Oct. 13 to 15.

The Annual Dinner this year has been scheduled during Auto Show week in New York on Nov. 14 and the National Transportation Engineering Meeting will take place in the same city from Nov. 14 to 16, during the National Motor Truck Show. Another big Transportation Meeting is scheduled for Nov. 3 to 5 in Los

Railroad and Automotive Engineers Hold Joint Meeting in Chicago, Oct. 4 & 5

Two-Day Program Includes Sessions on Diesel Engines And Air Conditioning

CHICAGO, the terminal of many railroads and one of the greatest truck and bus centers in the United States, will be headquarters for the technical men of two foremost transportation industries on Oct. 4 and 5, the dates of the SAE Truck, Bus and Railcar Meeting at the Blackstone Hotel.

Railroad and automotive engineers, whose problems have been brought closer and closer together with the adoption of Diesel engines as prime movers for crack passenger trains and the larger trucks, will discuss common problems and work together in seeking advancement of both industries, drawing from the knowledge of each.

While Diesel papers predominate, one session will be given over to the subject of air conditioning of buses, railcars and coaches. The air-conditioning engineer of a transcontinental railroad is presenting the paper.

The tentative program, which is practically buttoned up, shows for the opening day: a morning session devoted to the "Maintenance and Operation of Diesel-Electric Trains," a paper by E. F. Weber, superintendent of automotive equipment, Chicago, Burlington & Quincy Railroad; an afternoon inspection trip to the plant of the Electro-Motive Corp., and a dinner meeting in the evening at which the principal speaker is expected to be Walter E. Dunham, general superintendent, car department, Chicago & Northwestern Railway. His subject will be "Railcars, Streamliners and Buses."

The session on air conditioning will open the second day's program. This will be followed by an afternoon session at which James B. Fisher, vice-president, Waukesha Motor Co., will speak on "Comparison of Diesel, Semi-Diesel and Gas Power."

The completed program, which may change some of the details and include some papers not mentioned in this preview, will appear in the October SAE JOURNAL. In the meantime authorities of both industries will be asked to prepare discussion of the papers to be presented. At each session there also will be extemporaneous discussion from the floor.

SAE President C. W. Spicer sowed the seeds for this meeting in his inaugural speech at the 1938 Annual Meeting when he stressed the fact that the automotive and railroad fields have many interests in common and declared that greater cooperation between the two would result to the advantage of both.

Angeles, embracing West Coast T. & M. Activities.

Arrangements are already well under way for the Society's Annual Meeting which will be held in Detroit from Jan. 9 to 13, embracing practically every activity of the Society.

The greatest SAE event ever to be undertaken is the SAE World Automotive Engineering Congress which will bring engineers from all parts of the world to technical sessions in New York and San Francisco, the 500-mile race in Indianapolis, and to inspect the major automotive plants in Detroit. This international event will open in New York on May 22 and wind up in San Francisco on June 8. Further details appear on page 13.

Tulsa is Site for F. & L. Meeting, Oct. 6 & 7

Tulsa again is chosen for the SAE National Fuels and Lubricants Meeting, Oct. 6 & 7, when automotive engineers and technical men of the petroleum industry will take part in a well-rounded program sponsored by the Fuels and Lubricants Activity. The air-conditioned Hotel Mayo will be headquarters.

Arrangements are under the direction of Fuels and Lubricants Vice-President B. E. Sibley, Continental Oil Co.; General Chairman William F. Lowe, Natural Gasoline Association of America, and J. V. Brazier, Barnsdall Refining Corp., who is local chairman. Other committee members are T. J. Schuetz, Braden Winch Co.; A. V. Bourque, Western Petroleum Refiners Association; C. A. Tangner of the Tulsa Downtown Chevrolet Co., and G. C. Richardson, Indian Territory Illuminating Co.

Mr. Bourque will be chairman of the opening session to be devoted to "Motor Tune-Up and Servicing" by L. L. Fawcett, Auto Electric Co., and "Four Ball Testing Apparatus," a paper from Bataafsche Petroleum Maatschappij, Proefstation Delft, in The Netherlands. With Ralph R. Matthews in the chair, the afternoon session will concentrate on two papers devoted to the relation of lubricating oil to maintenance; one by Robert Collins, Kansas City Power & Light, and the other, a Western Petroleum Refiners Association paper, by J. V. Brazier, Barnsdall Refining Corp., and Sidney Born, Tulsa University. At dinner that night G. L. Wheatley, Petroleum Motor Transport Association, will give his views on the "Oil Industry's Automotive Maintenance Problems." Mr. Lowe will be dinner chairman.

"Developing Trucks and Trailers for Portable Well Drilling Work," by John D. Gordon, Dart Truck Co., and "Multicylinder Engine Adaptations in the Oil Industry," by H. W. Ladd, are papers scheduled for the second day's morning session, with Mr. Schuetz in the chair. In the afternoon F. M. Young and W. R. Ramsaur, Young Radiator Co., will present a paper on "Methods of Oil Temperature Control," and R. G. Horridge, Southwestern Bell Telephone Co., will speak on "Motor Vehicle Maintenance." Earle W. Pughe will preside.

Frank A. Suess will be chairman of the dinner that night featuring a debate on the subject, "Resolved: That Rear Engine Mounting is More Desirable than Forward Engine Mounting for Passenger Cars." Participating teams will be students of the Kansas State College and the University of Oklahoma.

Taub Explains

The Motor, ***an English publication, quotes SAE Member Alex Taub, of Vauxhall Motors, in explaining the difference between a scientist and an engineer.***

If both are given an aneroid barometer with which to measure the height of a building, he says, the scientist will note the barometer reading on the ground floor, take it up to the roof, note the reading again, correct the temperature difference, do some work on a slide rule and announce the building's height.

The engineer, Mr. Taub declares, will clamber straight to the roof, lower the barometer to ground level with the aid of a piece of string, and measure the string.

"Name" Luncheons Prove Successful

● Oregon

Friday noon luncheons of the Oregon Section have been well attended because of a plan originated by Chairman J. Verne Savage, and carried out through the cooperation of the membership.

Each luncheon program is assigned to a different Section member who is responsible for a half-hour program – and the luncheon is named after that member.

Two of the most successful of these luncheons have been held on "George Springer Day" and "Howard Morse Day." On his day Mr. Springer introduced Ed. Springer who gave a first hand account of the 500-mile race at Indianapolis. Captain Risley gave a motor tune-up talk as a part of Mr. Morse's program which also included Monk Watson, a famous comedian and slight-of-hand performer.

Supercharger Statement Corrected

F. M. OWNER of the Bristol Aeroplane Co., Ltd., in a discussion of the paper: "Supercharger Installation Problems," by Opie Chenoweth and A. L. Berger, presented at the second Aircraft Engine Session at the 1938 Summer Meeting of the Society at White Sulphur Springs, West Va., stated that Oscar Schey of the N.A.C.A. had "painted his picture of the gear-driven supercharger a little too black," in his discussion of the same paper – Mr. Owner referred to Mr. Schey's discussion instead of Mr. Chenoweth's paper as incorrectly reported on page 35 of the July, 1938, SAE JOURNAL.

General Motors Institute

(*Concluded from previous page*)

working off the campus. One chairman heads the two sections, but each section has its own vice-chairman and secretary-treasurer.

General Motors Institute had its origin in the Fall of 1919 as the School of Automotive Trades, devoted principally to spare time instruction in trade subjects pertaining to the automotive industry. In 1924 its present cooperative engineering program was established and its name changed to the Flint Institute of Technology. The Institute became affiliated with G.M.C. in 1926 and was moved to the present building and campus. At that time the present name was taken and the training program extended.

It is interesting to note that 92 per cent of the General Motors Institute graduates from the cooperative training program are now employed in the corporation.

During the 1936-1937 school year 12,380 men and women received full and part time instruction. Aside from the 562 students enrolled in the cooperative training program, the student body was comprised of the following:

Foremanship and Executive Training Program	7282
Industrial Spare Time Program	3256
Dealer Sales & Service Courses	695
Insurance Adjustment Courses	241
Warehouse Training Program	234
Automotive Teacher Courses	50
Graduate Accounting Course	37
Advanced Cooperative Engineering Course	23

Among those serving on the G.M.I. Board of Regents are SAE members: H. J. Carmichael, Harlow H. Curtice, F. S. Kimmerling, F. C. Kroeger, C. L. McCuen and E. B. Newill.

SAE *Coming* EVENTS

Truck, Bus and Railcar Meeting

Oct. 4-5 — Chicago
Blackstone Hotel

Fuels & Lubricants Meeting

Oct. 6-7 — Tulsa, Okla.
Hotel Mayo

National Aircraft Production Meeting

Oct. 13-15 — Los Angeles
Ambassador Hotel

West Coast Transportation and Maintenance Meeting

Nov. 3-5 — Los Angeles

Annual Dinner

Nov. 14 — New York City
Commodore Hotel

National Transportation Engineering Meeting

Nov. 14-16 — New York City
Hotel New Yorker

Annual Meeting

Jan. 9-13, 1939 — Detroit, Mich.

Buffalo – Sept. 13

Golf Meeting.

Canadian – Sept. 21

Royal York Hotel, Toronto; dinner 7:00 P.M.

Cleveland – Sept. 12

Cleveland Club; dinner 6:30 P.M.

Metropolitan – Sept. 15

Manhasset Bay Yacht Club, Long Island, N. Y. Leaving New York City at 3:00 P.M., members and guests will enjoy an afternoon and evening of swimming, bridge, tennis, and an inspection of oceanic type airplanes, with dinner and dancing in the evening.

Milwaukee – Sept. 16

Golf meeting at Racine, Wis. Dinner at 6:30 P.M., with presentation of golf awards and extemporaneous speeches.

Northern California – Sept. 13

Hotel Leamington, Oakland; dinner 6:30 P.M. Navigating the Clipper Ship to Honolulu – George W. Smith, operation engineer, Pacific Division, Pan American Airways. Recent Engineering Developments in the Aircraft Industry – Fred W. Herman, assistant to chief engineer, Douglas Aircraft Co.

Northwest – Sept. 9 and 28

Sept. 9 – New Washington Hotel, Seattle, Wash.; dinner 6:30 P.M.

Sept. 28 – New Washington Hotel, Seattle, Wash.; dinner 6:30 P.M. New Firing Lines for Engineers – C. W. Spicer, vice-president, Spicer Mfg. Corp., and president, SAE. Truth Through Torture – John A. C. Warner, secretary and general manager, SAE.

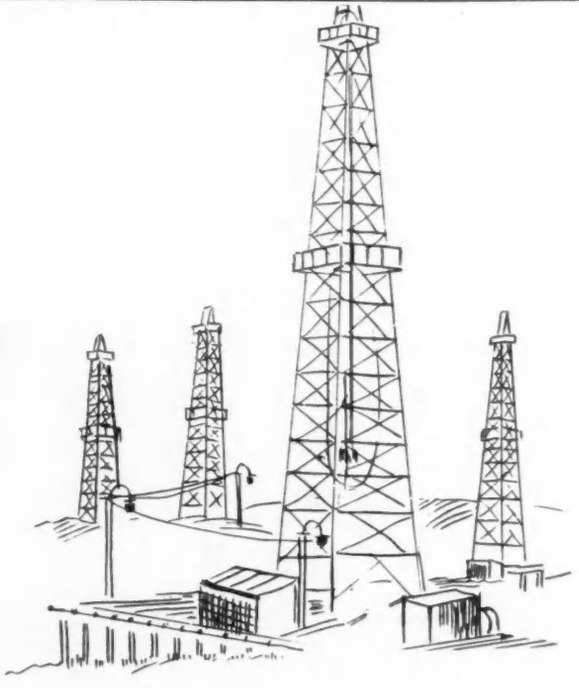
Oregon – Sept. 30

Portland; dinner 6:30 P.M. New Firing Lines for Engineers – C. W. Spicer, vice-president, Spicer Mfg. Corp., and president, SAE. Truth Through Torture – John A. C. Warner, secretary and general manager, SAE.

At TULSA

OCTOBER

6th and 7th



National

FUELS & LUBRICANTS

Meeting

Knock-Testing – In the Laboratory and in Service

(*Continued from page 12*)

mathematical functions of the ratings given by the laboratory methods. (A simple illustration of this principle is the use of the mean between the A.S.T.M. and the Research methods which apparently for the 1937 cars gives correlation at least as good as any single method.)

Whether or not this principle is possible of practical achievement is not known at present, but there are indications that it may be possible and, if so, the writer feels it to be a most valuable contribution to the entire correlation problem.

Let us assume, for the sake of argument, that two laboratory methods are available, M and S, the former representing "mild" conditions and the latter "severe." Let the ratings (octane numbers) of individual fuels by these methods be M_1, M_2, and S_1, S_2, and so on. Let the "average road octane numbers" of these fuels be R_1, R_2, and so on with the subscripts w, f, s, representing ratings under mild, average, and severe test conditions respectively, then it is quite possible that we could find the following equations holding reasonably well:

$$R_{1w} = a + b\,(M_1 - S_1) + M_1$$
$$R_{2w} = a + b\,(M_2 - S_2) + M_2, \text{ and so on.}$$

and

$$R_{1f} = c + d\,(M_1 - S_1) + M_1$$
$$R_{2f} = c + d\,(M_2 - S_2) + M_2, \text{ and so on.}$$

and

$$R_{1s} = e + f\,(M_1 - S_1) + M_1$$
$$R_{2s} = e + f\,(M_2 - S_2) + M_2, \text{ and so on.}$$

Where a, b, c, d, e, and f are constants (a, c, and e may or may not be zero).

It appears to the writer that it is of utmost importance that those agencies working on the correlation problem shall give very serious consideration to the possibilities of developing such laboratory methods as these.

What are the advantages of such a system of measurement?

1. Every fuel is rated by two definite methods irrespective of the final decision as to the utilization of the data thus obtained.

2. From these two ratings the approximate road antiknock ratings of the fuel under any conditions can be calculated.

3. If it is decided to utilize only a single octane number for the sale of gasoline, this number can be calculated readily from the two laboratory ratings.

4. To such an extent as may be deemed practicable, ratings corresponding to varying conditions could be calculated without changing the laboratory technique. Thus, seasonal and geographic changes *could be* made for the country if justified; even individual large contractors could specify the antiknock characteristics of their fuel to meet their own needs; flexibility to meet varying needs could be given.

5. From an international viewpoint, it would be possible for all nations to agree on the *technique* of laboratory determinations, but the *calculated* ratings could be varied to suit the requirements of the cars and temperatures of the country in question. (Certainly it would appear that fuel ratings in Sweden should be on a different basis from those in India!)

6. As "average road ratings" may be expected to change from year to year with changes in the characteristics of new cars, it would be possible to retain the two basic laboratory ratings, and merely change the mathematical formula, in order to obtain ratings agreeing with the new road ratings.

What are the disadvantages?

Largely the complication of the laboratory technique and the increased cost of control operations.

It is, of course, true that, the simpler and easier the laboratory method, the better from many standpoints, but it is the writer's opinion that the importance of increased knowledge of the properties of gasoline under varying conditions is so great that the cost of obtaining such information is well justified.

Conclusions

The writer has attempted to list a number of the experimental facts and to outline a number of the problems relating to the question of laboratory knock-ratings and their relation to service conditions. He has deliberately stressed the limitations of the problem because in the past, he has felt that these limitations have been neglected and that, in some quarters, a significance has been attributed to both laboratory and road knock-test data which these data do not possess and cannot possess. It might be concluded that the writer feels pessimistic to the extent of arguing that knock-test data have no significance. This is by no means the case.

In the first place, the establishment of the octane-number scale and a uniform laboratory test method has contributed greatly to increased uniformity of antiknock value of fuels, and has provided a basis for the gradual but sure improvement in antiknock value which has occurred over a period of years. It also has been of the greatest service to the automotive manufacturer in permitting him to design his engines to take advantage of available fuels.

In the second place, although the laboratory octane numbers never *have* and never *can* measure accurately the performance of an individual fuel in an individual car, it is still true that, for the great majority of fuel sold in the United States, the laboratory octane number can be made to reflect service performance fairly well. This is true because of the fact that this great majority of fuel (whose octane number is of commercial interest) is similar in chemical type – namely a blend of cracked and straight-run gasoline containing tetraethyl lead. The fuels whose road behavior is most difficult to interpret by laboratory method – for example, highly cracked fuels of high antiknock value, benzol and alcohol blends, and straight-run highly volatile gasolines with or without tetraethyl lead – constitute a relatively small proportion of the total gasoline sold and, as a result our *average driver*, in an *average car*, driving in *average weather*, and buying *average fuel*, does not frequently experience the large discrepancies between laboratory and road ratings listed previously. Nevertheless, these discrepancies exist and will continue to exist, and efforts to overlook them seem to the writer ill-advised, at least as far as the technical man is concerned.

Summary

1. An individual test of the antiknock value of a fuel in an individual car on the road is actually an attempt to evaluate the psychological reactions of "the average driver," and may or may not reflect the reactions of any *individual* driver.

2. The road knock-rating of a fuel may vary enormously in different cars and in the same car under different conditions. For this reason, the "average road rating" tells little of the behavior of any fuel in any individual car and, conversely, the road rating of a fuel in any individual car tells little of the average rating.

3. Average road ratings, of practical necessity, are subject to

substantial error of experiment and interpretation. It is not to be expected that any average data ever will be secured to which no objections can be raised.

4. Laboratory antiknock ratings are made for the purpose of maintaining specifications. The best that can be expected of them from any other viewpoint is that they will reflect reasonably such "average road ratings" as can be agreed upon. It is not to be expected that such reflection should be more than approximate.

5. No single laboratory method ever can reflect more than a single "average road rating." Since average road ratings vary with conditions of test, we must either have a single laboratory method corresponding to average conditions or several ratings corresponding to different conditions. Each of these alternates offers certain practical disadvantages.

6. There is much to be said for the development of two (or more) laboratory methods corresponding to extremes of mild and severe conditions with proper allowance for volatility effects. If it can be established that average road ratings under different conditions can be expressed reasonably well as mathematical functions of the laboratory ratings by these two methods, a flexible knock-rating system is provided which represents probably the best practical solution of a problem which, fundamentally, is not capable of complete technical solution.

Part II – The Airplane

Introduction

The problem of knock in the aircraft engine in service is one of very vital importance since an airplane cannot get off the ground and stay in the air if the fuel is inadequate from an antiknock standpoint. Here we are not concerned with psychological reactions or with temporary inconvenience – we are confronted with engine failure and probable disaster. For this reason, the problem of service antiknock ratings and the correlation with laboratory methods is one of the utmost importance. As in the case of the automobile previously discussed, the problem is complicated and difficult from the technical standpoint and no complete solution has been achieved or is apt to be achieved. From the practical standpoint, however, the problem is much simpler than is the case with automobile fuels. The volume of aviation gasoline is relatively small and, in the past, the petroleum and aircraft industries have been able, through cooperative effort, to limit the types of commercial aviation fuel to those whose service characteristics were well known. This limitation has been done partially by the addition to laboratory knock specifications of chemical or other specifications designed deliberately to exclude fuels whose service characteristics were doubtful in any way.

Much valuable experimental work has been done and is being done on the problem of antiknock methods and tests, and it is the purpose of the writer merely to outline some of the broad aspects of the problem, without attempting even to suggest an answer to the specific problems which arise.

Service Knock Tests on Aviation Fuels

Failure of an aviation fuel in service may manifest itself in one of several ways:

1. A sudden increase in cylinder-head temperature may occur, accompanied usually by audible knock. If the engine continues to operate under these conditions, the knock passes rapidly into preignition and loss of power occurs, coupled perhaps with serious damage to the piston.

2. With certain types of fuel there is apparently a direct transition from normal combustion to preignition without the intermediate knock, but resulting in engine failure as before.

3. Apparently, when cruising with quite lean mixtures, evidence (in the shape of damaged pistons) may be found of irregular combustion which has not been detected by rise in cylinder temperature or by audible detonation. It is probable that this type of fuel failure is actually light knock, occurring under conditions in which the efficiency of the cooling system prevents an appreciable rise in cylinder-head temperature.

For the purposes of this paper, the term "knock" will be considered as including fuel failure of any type resulting from abnormal combustion.

It is clearly impracticable to carry out knock tests on aviation fuels in aircraft flight and, for this reason, all so-called service tests have been carried out on aircraft engines attached to a dynamometer. The type of test employed in the United States today is as follows:

The engine used is coupled to a dynamometer and equipped with the necessary means for measuring fuel flow, the temperature of all cylinder heads and bases if air-cooled, or of all spark-plugs if liquid-cooled.

It has been found desirable to run tests under both rich-mixture take-off, and lean-mixture cruising conditions. From laboratory determinations of the octane number of the test fuel, the power outputs necessary to stress it suitably at both take-off and cruising conditions are chosen. Using a normal commercial fuel of the same laboratory octane number as the test fuel, the engine is warmed up and its performance checked with the power output, manifold pressure, and specific fuel consumption normal for the laboratory fuel at either take-off or cruising conditions. If the engine condition and performance are satisfactory on the normal laboratory fuel, the carburetor mixture control is moved to full rich without change of any other condition and the fuel supply switched over to the test fuel. With rate of revolution held within approximately ± 20 r.p.m. power output, fuel flow, cylinder base, and head temperature (for air-cooled engines) are determined after the engine has settled down to equilibrium condition. The carburetor mixture control is then adjusted to reduce the total fuel flow by about 5 per cent and readings again are taken after equilibrium is established. Successive steps of leaning off the carburetor by approximately 5 per cent reductions of total fuel flow are then carried out until:

1. The cylinder temperatures rise excessively.

2. The exhaust gives signs of abnormal combustion which may damage pistons without producing excessive cylinder temperature.

3. The power output has passed through a maximum and fallen to 95 per cent or less of that maximum.

4. The specific fuel consumption has passed through a minimum and then sharply increased on leaning from the fuel flow giving that minimum.

When conditions as just outlined have been reached on the test fuel, the carburetor again is set to full-rich and the fuel supply switched to a reference fuel which is judged to be either slightly better or slightly worse than the test fuel. The procedure of progressive leaning off is then carried out with the reference fuel until one of the conditions (1) to (4) inclusive given previously occurs. Leaning-off tests are repeated with reference fuels until blends are found which are about 2 octane numbers better and 2 octane numbers poorer than the test fuel which is thus bracketed.

The complete procedure set-up by the Aviation Fuels Committee of the C.F.R. for conducting full-scale knock tests for aviation fuels has been discussed by C. B. Veal.[1]

There is perhaps not complete agreement among all authorities as to the exact interpretation of the data but, on the

[1] See S.A.E. TRANSACTIONS, May, 1936, pp. 161-175: "Rating Aviation Fuels in Full-Scale Aircraft Engines," by C. B. Veal.

whole, the problem in this regard seems simpler than is the case with the automobile and its fuel. In any case, the experimental data give for each engine and each fuel a "service knock-rating" in terms of certain secondary reference fuels, and this rating is probably, in most cases, a fair measure of the usefulness of the fuel in the particular engine in question.

When sufficient individual ratings of this type have been accumulated to cover all important aircraft engines and all types of fuel likely to be of commercial interest, it becomes necessary to consider the statistical methods to be employed in handling the data in order to form a basis for the development of a laboratory knock-testing method which shall be used for the rating of aviation fuels. At this point, we leave the terra firma of experimental fact behind and embark once more on the troubled seas of opinion!

In the corresponding case of the road ratings of automobile fuels, it is undoubtedly correct to employ some methods of *averaging* the experimental road ratings in order to arrive at a basis for the development of a laboratory method.

The writer feels that this method should not be employed in the case of aviation fuels. In the case of the automobile, if an individual fuel does not perform in service as well as its laboratory rating would indicate, little harm is done except annoyance or delay; in the case of an aviation fuel, any substantial failure of the fuel to perform as rated may be followed by disaster. For this reason, the writer feels that the *minimum service rating of a fuel in any engine* should be taken as the basis upon which to develop the laboratory method for rating aviation fuels. If it should prove to be possible to develop a laboratory knock-test method which gives results agreeing with these minimum service ratings, then any fuel would behave in service *at least as well as its laboratory rating*. Certainly this principle would penalize fuels whose behavior is much better in some engines than in others, and such penalty should be kept at a minimum but, where human life may be at stake, the commercial interests must not be weighted too highly.

It should be pointed out, however, that, in the practical application of the foregoing "minimum-rating" principle, certain problems arise which need discussion. As indicated previously, the "service ratings" of each fuel are obtained by comparison with certain reference fuels and reported in terms of such reference fuels. The reference fuels which have been used in this country have been, in general, straight-run gasolines and blends thereof with tetraethyl lead and/or isooctane. Reference fuels *could* have been used, however, consisting of such products as benzol blends. Now the relative ratings of different fuels in the same engine, and the "average rating" of fuels in different engines are not affected by the nature of the reference fuels used, but the *minimum ratings are affected*. The nature of the reference fuel does not affect the "minimum-rating principle" for, no matter what reference fuels are used, a laboratory rating corresponding to the minimum service rating will make certain that all fuels perform at least as well as their rating, but the choice of reference fuels does determine which fuels are penalized, and to what extent. It would appear that a fair solution of the problem of reference fuels is the continuation of the principle heretofore employed – that the reference fuels employed should consist of products whose antiknock value changes as little as possible with engine conditions, at least so long as the great majority of aviation fuels belong to this general class. Under these conditions, the minimum-rating principle appears to the writer to be the soundest that can be developed.

Laboratory Test Methods

Whatever principle of selecting service ratings is agreed upon, it is by no means certain that any one laboratory method can be devised which will duplicate them satisfactorily. The important range of octane number is much greater in the aircraft field than in the automobile field; the aircraft engine, both in design and in conditions of operation, is a far cry from any laboratory instrument yet devised and, although the chemical nature of the aviation fuels in the past has been rather simple, it appears that, in the future, it is apt to be more diverse than is the case with automobile fuels.

It seems very probable to the writer that (1) different test-methods for different octane-number ranges may need to be developed; (2) chemical tests may be necessary to eliminate certain types of fuel; (3) it may prove to be desirable to develop two tests at varying "severity levels" to evaluate properly fuels of high sensitivity to conditions of test.

Such tests as item (3) might enable an airline operator, for example, whose entire equipment was known to rate sensitive fuels higher than the minimum ratings previously mentioned, to specify such fuels by means of a "sensitivity specification," and thus utilize to advantage fuels which would not perform satisfactorily in general use.

It is too early to predict what the possibilities of laboratory methods may be; it is fortunate, however, that, regardless of how satisfactory the laboratory tests may be, it is probable that, in the future as in the past, aviation fuels will be service-tested thoroughly before they are sold commercially and that commercial fuels will be limited to satisfactory types, whether or not it is possible to write entirely satisfactory specifications concerning them.

Defends C.F.R. Knock-Testing Correlation Work

–J. O. Eisinger
Standard Oil Co., (Ind.)

THE author has presented an extensive analysis of the numerous factors involved in knock-testing work, ostensibly to convince his readers that the problem of correlating road and laboratory ratings is exceptionally complicated. After reading the author's paper, one is tempted to conclude that a satisfactory solution to the problem is more remote today than ever before, despite the tremendous amount of independent and cooperative test work which has been completed since 1932. The work that has been done has brought to light all of the factors mentioned by the author, some indeed which he fails to mention. At the same time, these investigations have contributed much to the understanding of each of these factors, indicating those which merit adjustments and those which should be neglected as unimportant. Dr. Edgar is not alone in his realization that no laboratory knock test method can be developed which will reflect service performance *perfectly*. On the other hand, the problem of developing a laboratory method which will give knock ratings in *substantial* agreement with road knock determinations is far less confusing and, we feel, much nearer solution than the writer intimates.

The author concludes that "it is not to be expected that any average road data ever will be secured to which no objections can be raised." Based on past experience, there can be no argument with this conclusion. In his paper he presents a veritable array of objections to the 1937 C.F.R. knock-test program, the most comprehensive of its kind ever undertaken. His objections have to do, first, with the inadequate coverage of each independent variable affecting knock ratings, and second, with the diverse conditions under which fuels were tested by different operators. Perhaps it has not occurred to the writer that the very diversity of the conditions under which each fuel was tested provided a very desirable cross-section of the numerous variables he mentions.

Apparently the author was keenly disappointed when the 1937 C.F.R. road-test data failed to show a more definite effect of atmospheric temperature on road knock-ratings. What Dr. Edgar's reaction might have been had the 1937 data confirmed the earlier work of the Ethyl Gasoline Corp. only can be surmised. The author expresses the opinion that the effect of atmospheric temperature can be ascertained most satisfactorily by making use of the data of one laboratory. The data of each individual laboratory which participated in the 1937 C.F.R. program are at the author's disposal in the event that he is interested seriously in substantiating his opinion in this way. We concur with the conclusions reached by the Cooperative Fuel Research Committee with regard to atmospheric temperature effect not only because its 1937 data confirm our own experience, but also because we know of no other data at

variance with it as comprehensive or as truly cosmopolitan in character.

Each of the summer and winter preferred road-test fuels included in the 1937 program was tested in approximately 50 different cars. From the paper by Campbell and Lovell,[a] there is only one chance in ten that the average fuel tested would have had a mean road rating differing by more than about 0.5 octane number from the result actually obtained even though it has been tested in an infinite number of cars – only one chance in a thousand that the difference would exceed 1.0 octane number. This degree of certainty was obtained even though the fuels were tested at the many different atmospheric temperatures and under the many different operating conditions mentioned by the author.

[a] See "Application of Statistical Concepts to the Knock-Rating Problem," by John M. Campbell and W. G. Lovell, presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, June 16, 1938.

Since the writer feels that the knock-rating problem is so complicated, he should agree that hasty technical decisions should be avoided. In particular, we should avoid wholesale acceptance of experimental evidence which introduces some entirely new phase of the problem or perhaps one hitherto not seriously considered. It is not our intention to infer that we should ignore new and constructive evidence; on the contrary, it should be accepted and allocated to its proper status as part of the whole problem after confirmation by a majority of those concerned.

After reading the author's convincing arguments concerning the inaccuracies and difficulties of interpretation of road tests and the general hopelessness of obtaining definite technical data of broad applicability therefrom, we were curiously surprised to find him emphasizing the need for close correlation between laboratory and road ratings even at the expense of a multiple-method scheme of knock-testing.

New Members Qualified

These applicants who have qualified for admission to the Society have been welcomed into membership between July 15, 1938, and Aug. 15, 1938.

The various grades of membership are indicated by: (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate Member; (SM) Service Member; (FM) Foreign Member.

Baltimore Section

TAYLOR, J. MALLORY, JR. (A) president, Ditch, Bowers & Taylor, Inc., North and Mt. Royal Aves., Baltimore, Md.

Chicago Section

AUKERS, ALBERT J. (M) engineer Victor Mfg. & Gasket Co., 5750 W. Roosevelt Road, Chicago. (mail) 7154 S. Fairfield Ave.

BEHNKE, ELMER R. (A) assistant manager of delivery, service division, Marshall Field & Co., 601 W. Polk St., Chicago.

BRYANT, EDWIN E. (A) sales engineer, acoustic division, Burgess Battery Co., 500 W. Huron St., Chicago.

DULYN, FRANCIS WINTHROP (J) apprentice engineer, United Air Lines Transport Corp., 5936 S. Cicero Ave., Chicago.

LONG, LEWIS T. (J) junior engineer, United Air Lines Transport Corp., 5936 S. Cicero Ave., Chicago.

MCMULLAN, ORIN W. (M) metallurgist, Youngstown Sheet & Tube Co., East Chicago, Ind.

MOULTON, ROLLIN H., JR., (J) apprentice engineer, United Air Lines Transport Corp., 5959 S. Cicero Ave., Chicago. (mail) 4519 Lawn Ave., Western Springs, Ill.

Cleveland Section

MAKLEY, WILLIAM C. (M) chief works engineer, Timken Roller Bearing Co., Canton, O. (mail) 1033 Linwood Ave., S.W.

Detroit Section

GOGOL, LEW (J) 3839 Gilbert Ave., Detroit.

HENGEL, FRED, JR. (J) body drafting, Fisher Body Corp., Detroit. (mail) 1612 Hoffman, Royal Oak, Mich.

STRAUB, PAUL F., JR. (J) junior engineer, Chrysler Corp., Highland Park, Mich. (mail) 111 Highland Ave.

WEINBERG, EDWARD J. (M) chief engineer, Saginaw Steering Gear Division, General Motors Corp., Saginaw, Mich. (mail) 2834 State St.

Indiana Section

BOWES, CHARLES E. (A) vice-president, charge of purchasing and production, Bowes Seal Fast Corp., 226-30 N. Pine St., Indianapolis.

Metropolitan Section

BRITTON, JOHN A., JR. (A) manager, Paraflow Sales Division, Standard Oil Development Co., Room 839, 26 Broadway, New York.

DONOHUE, GUY B. (A) automotive engineer, sales promotion, Ethyl Gasoline Corp., Chrysler Bldg., New York. (mail) 72 Hudson Ave., Haverstraw, N. Y.

ELBRECHT, ROBERT J. (A) designer, Elbrecht Engineering Co., 90 Alexander St., Newark, N. J.

FISHER, DAVID A. (M) instructor, mechanical engineering, School of Technology, College of the City of New York, 140th St. and Amsterdam Ave., New York.

LANDES, WILLIAM S. (M) president, Celluloid Corp., 290 Ferry St., Newark, N. J.

WENK, CHARLES S. (A) owner, general manager, 38 Jefferson Ave., Elizabeth, N. J. (mail) 226 Rahway Ave.

New England Section

NARGIS, GEO. S. (A) service manager, Middlesex Sales, Inc., 127 Main St., Medford, Mass. (mail) 90 Webster St., Arlington, Mass.

Northern California Section

HEAKIN, HAROLD L. (A) sales, Pacific Foundry Co., 3100 19th St., San Francisco. (mail) 1511 Waverly St., Palo Alto, Calif.

Philadelphia Section

GRISWOLD, FRANK TRACY (A) treasurer, Griswold-Wilson, Inc., 25 Rittenhouse Pl., Ardmore, Pa.; president, F. T. Griswold Co., Radnor, Pa. (mail) care of F. T. Griswold Co.

HODER, FRANK JOSEPH, JR. (J) charge, experimental laboratory, Philadelphia div., National Supply Co., State Road and Rhawn St., Philadelphia, Pa. (mail) care of T. E. Cahill, Sunset Hollow Farm, West Chester, Pa.

St. Louis Section

DREHER, HEDLEY R. (M) chief engineer, Bondall Co., 500 Bittner St., St. Louis, Mo.

Southern California Section

CARHART, W. H. (A) sales manager, equipment division, Jadson Motor Products Co., Div. Thompson Products, Inc., 8354 Wilcox Ave., Bell, Calif.

CORNELL, SIDNEY (J) gear engineer, Fellows Gear Shaper Co., Springfield, Vt. (mail) 3306 Wyoming Ave., Burbank, Calif.

ITEN, FRED, JR. (A) mechanic, Auto Centre Garage, 746 S. Hope St., Los Angeles. (mail) 122 E. 85th St.

Washington Section

CAMPBELL, ALBERT F. (A) district manager, Timken Roller Bearing Co., 519 Transportation Bldg., Washington, D. C.

Outside of Section Territory

GUIBERSON, ALLEN (A) vice-president, Guiberson Corp., Guiberson Diesel Engine Co., Dallas, Tex. (mail) P. O. Box 1106.

MILLER, ARTHUR DALE (J) junior engineer, Ethyl Gasoline Corp., 305 S. Kenosha Ave., Tulsa, Okla.

PARKER, JAMES HODGES (J) inspector, Virginia Electric & Power Co., Richmond, Va. (mail) 117 St. James Ave., Suffolk, Va.

POWELL, KNOX A. (M) research engineer, Minneapolis-Moline Power Implement Co., Minneapolis, Minn. (mail) 1008 18th Ave., S.E.

SLATER, E. J. (A) general superintendent, Champlin Refining Co., Enid, Okla.

Foreign

DACCO, A. A. (F M) general manager, S. A. Impresa Forniture Industriali, Milano, Italy. (mail) 5 Via Arnaldo Mussolini, Milano 1/28, Italy.

LAMBERT, CHARLES A. (F M) general manager, Pechelbronn—Antar, 4, rue Roussel, Paris, France.

SCHLUMBERGER, R. A. (F M) co-manager, Pechelbronn S.A.E. M., 32 Allee de la Robertsau, Strasbourg, France.

Applications Received

The applications for membership received between July 15, 1938, and Aug. 15, 1938, are listed herewith. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

Chicago Section

TOBIN, THOMAS T., chief engineer, E. Edelmann & Co., Chicago.

Cleveland Section

GOODAIRE, EDWIN W., owner, Ring-Free Oil Co. of Cleveland, Cleveland.

Dayton Section

HARRISON, JOHN F., mechanical engineer, Huber Mfg. Co., Marion, O.

JOLLEY, FRANK E., chief, Division of Motor

Transportation, State Highway Dept., Columbus, O.

Detroit Section

BEYSTER, HENRY E., commissioner public works, City of Detroit, Detroit.

SHERMAN, GEORGE D., experimental test engineer, Mallory Electric Corp., Detroit.

Kansas City Section

DRANEY, JOHN J., detail draftsman, Weber Engine Co., Kansas City, Mo.

Metropolitan Section

BUXBAUM, LEO JOHN, 118 East 40th St., New York.

ELDORA, JAMES, owner, Rex Super Service Station, Brooklyn, N. Y.

HAINES, PAUL L., research engineer, Standard Oil Development Co., Bayway, N. J.

HALL, THOMAS JOHN, inspector, Brooklyn Bus Corp., Brooklyn, N. Y.

KAMIJO, TSUTOMU, engineer, Mitsubishi Shoji Kaisha, Ltd., New York.

REMO, JOHN G., salesman, A. Jacoby & Sons Inc., Brooklyn, N. Y.

New England Section

FLYNN, DONALD S., assistant division manager, Ethyl Gasoline Corp., Boston, Mass.

Northwest Section

LOUDEN, VERGIL W., shop foreman, Pacific Highway Transport, Seattle, Wash.

SHARKEY, H. J., sales manager, Hoge Piston & Ring, Inc., Seattle.

Southern California Section

BURTON, ALEXANDER T., engineering test pilot, North American Aviation, Inc., Inglewood, Calif.

HEINE, C. J., engineering draftsman, Douglas Aircraft Co., Inc., Santa Monica, Calif.

SMITH, W. S., assistant to refinery engineer, Wilshire Oil Co., Inc., Norwalk, Calif.

Southern New England Section

CROOK, FRANK, salesman, Raybestos Division of Raybestos Manhattan, Inc., Bridgeport, Conn.

Washington Section

RUTENBERG, NICHOLAS, owner, Rutenberg Tire Co., Inc., Richmond, Va.

Outside of Section Territory

BOTNEN, KARL ORVILLE, instructor, Post Motor School, U. S. Army, Schofield Barracks, Territory of Hawaii.

HENNEY, JOHN W., president, Henney Motor Co., Freeport, Ill.

WARD, FRED R., superintendent of equipment, Mistletoe Express Service, Inc., Oklahoma City, Okla.

Foreign

ANDREWS, HAROLD, managing director, Harold Andrews Grinding Co., Ltd., Birmingham, England.

FIRMAN, FREDERICK CHARLES, senior service manager, J. E. Peach & Coy, Ltd., Napier, Hawkes Bay, New Zealand.

KIRKHAM, NORMAN H., transport officer, The Texas Co. (A'Sia) Ltd., Wellington, N. Z.

STADLER, ALFRED E., assistant to mechanical superintendent, Cape Provincial Roads Department, Cape Town, South Africa.

TULLY, ALAN CARR, manager, Australasia & New Zealand, Ethyl Export Corp., Melbourne, Australia.

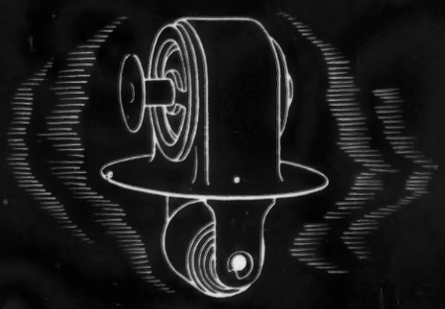
About Authors

(Continued from page 5)

over the design and patents in 1920, he joined them as chief engineer. Since then he has supervised the production of several successful types of poppet-valve engines, culminating in the "Mercury" and "Pegasus" series, and has been engaged in valuable research work on sleeve-valve engines. Mr. Fedden is a member of the SAE Overseas Relations Committee and has served as chairman of the Manly Memorial Medal Committee. He visited the United States to present his paper at the Summer Meeting.

● **Robert N. Janeway** *(M '29) went to work for General Motors Research shortly after getting his M.E. degree from Cornell. There he remained from 1922 to 1927, devoting much of his time to problems of thermal efficiency of automobile engines. Following a year as research engineer with Dodge, Mr. Janeway devoted himself to consulting work from 1928 to 1931, giving special attention to combustion chamber design. During this period he invented some new combustion chamber forms which proved to be important contributions to thermal efficiency. In 1931, he joined the Chrysler Corp. engineering department, concentrating still in the research division. He is now in charge of*

(Continued on page 23)



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About SAE Members:

Aircraft Men

JOHN C. HANSON has joined E. G. Budd Manufacturing Co. as aeronautical engineer. . . . **HARRY D. GOLDSTEIN,** former propeller engineer, Aviation Manufacturing Corp., is with Curtiss Aeroplane Division, Curtiss-Wright Corp., Buffalo, as engineer, structures department. . . . **MAJ. E. E. ALDRIN,** consultant, and **E. W. CLEVELAND,** Cleveland Pneumatic Tool Co., have accepted membership on the advisory committee of the Association of Men With Wings, recently organized to sponsor a campaign for the return of the original Wright airplane to the United States from the Kensington Museum, London, where it is now sheltered. . . . President Roosevelt recently reappointed SAE members **E. P. WARNER, JEROME C. HUNSAKER** and **ORVILLE WRIGHT** to the National Advisory Committee for Aeronautics for a five-year period in accordance with the Civil Aviation Act which limits the term of a civilian member of the N.A.C.A. to that number of years.

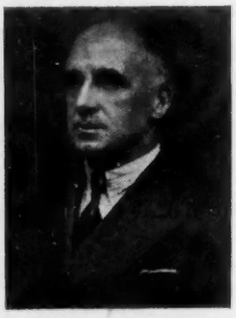
R. N. JANEWAY, who with **E. H. KELLEY** represents the Society's Detroit Section on the Affiliate Council of the Engineering Society of Detroit, has been elected chairman of that council.

F. S. KIMMERLING, general manager, AC Spark Plug Division of GMC, has been granted a leave of absence because of ill health.

REID RAILTON, who designed and built the 2500 hp. streamlined racer with which John R. Cobb will attempt to break existing land speed records, arrived in New York early last month on his way from England to the Bonneville Salt Flats in Utah, where the speed trials will be held as soon as the road bed is solid enough.

Foreign News

JOHN WILLIAM MILLS has left the Austin Motor Co., Ltd., Birmingham, England, where he was production manager, to take up an appointment in the Air Ministry. . . . **OTTO LOHMANN,** Dipl. Ing., who has been adviser to the National Government of China, has been recalled to Germany by his government. . . . **HELMER PETTERSON,** formerly engineer with Gustaf Byrenius, Stockholm, Sweden, has taken the position of service manager with Gustafsson & Gortz, Orebro, Sweden.



J. W. Mills
To Air Ministry

C. S. ASH, formerly consulting engineer of Kelsey-Hayes Wheel Co., and active in the development and manufacture of automotive wheels and axles for the past 25 years, has been elected president of the Detroit Compensating Axle Corp., Detroit.

C. S. Ash
Elected President

Items

WALT WHITEMAN, who was loaned to the Leaf Spring Institute to engage in research work, has returned to his job as chief engineer of William & Harvey Rowland, Inc., Philadelphia. . . . **RAYMOND LOEWY,** industrial designer, styled the buses which will be used to carry some 30,000,000 visitors through the grounds of the New York World's Fair in 1939. . . . **ALFRED P. SLOAN, JR.,** chairman of the board, General Motors Corp., and Mrs. Sloan, sailed for Europe late in July. They are expected back early in September. . . . **W. E. POWELSON,** new chairman of the Southern California Section and master mechanic, Los Angeles Fire Department, writes that he has been given 25 pieces of forest fire fighting apparatus to look after in addition to the 40 pieces in the city's fire protection districts. . . . **WALTER S. PEPER** is general manager of the National Motor Truck Show to be held in New York, Nov. 12 to 17.

Mayor Reading of Detroit has appointed SAE members **WILLIAM S. KNUDSEN, WILLIAM B. STOUT, COL. J. G. VINCENT** and **GAR WOOD** to a committee of seven which is investigating charges that the Detroit City Airport is not being economically run.

R. F. NORRIS has organized Norris Industries, Inc., and will operate as an independent acoustical and sound engineer. He also expects to market several small devices of his own invention, one of which is a filter to be installed in a window to render incoming air pollen-free and relieve hay fever suffering. Prior to this new activity, Mr. Norris has been well-known throughout the industry as research engineer for C. F. Burgess Laboratories, Inc.

Yachts

The Manhasset (Long Island) theatre program tells that Bendix Aviation Corp. Vice-President **VICTOR W. KLIESRATH,** who recently came East to direct the company's new marine development division, has brought his yacht "Yap Yap" to Long Island waters. . . . It adds that Mr. Kliesrath thinks its name would be more appropriate if spelled backwards. . . . **CHESTER S. RICKER,** technical counsel, Detroit office, McCann-Erickson, Inc., heads the Detroit Gold Cup Regatta Race Committee. The race is to be held on Labor Day.

HENRY FORD was awarded the Grand Cross of the German Eagle for his industrial accomplishments, on July 30, his 75th birthday. He is the first American to receive this decoration which is the highest German award to a foreigner. More than 1400 sat down with Mr. Ford at his birthday dinner at which **WILLIAM S. KNUDSEN** and other friends of the automobile manufacturer spoke. Mr. Ford recently accepted honorary chairmanship of the Advisory Committee for the Society's World Automotive Engineering Congress to be held in 1939. . . . Another SAE member to be honored by the German Government is **J. D. MOONEY,** president, General Motors Export Co., who was awarded the Order of Merit of the German Eagle, first class, on Aug. 10.

E. H. KELLEY has been advanced to production engineer of the Chevrolet Motor Division of GMC. He is chairman of the Detroit Section's membership committee.

E. H. Kelley
Advanced

EARL W. DILG, formerly general manager of the Autopulse Corp., is now connected with the King-Seely Corp., in the latter's fuel pump activity.

New Connections

Past SAE President **A. J. SCAIFE,** former Autocar engineer, has joined Dean Gillespie & Co., of Denver as consulting engineer. . . . **CLINTON BRETTELL,** formerly in charge of the R. H. Macy department store fleet, is affiliated with the E. R. Merrill Spring Co., New York, as sales engineer, national accounts. . . . **CLYDE A. DIVELY** left the engineering department, City of Cleveland, parks division, to join the Detroit Diesel Engine Division of GMC. . . . **EDWIN L. ALLEN** recently joined the Reid Products Division of Standard Products Co., Cleveland, as sales engineer. . . . **H. T. McKINLEY** is service manager of Rolland Motors Co., Inc., Hartford, Conn.

Transfers

LOWELL S. HARDING, airline inspector, United States Department of Commerce; from Washington, D. C., to the Newark, N. J., airport. . . . **H. I. GLASHOFF,** lubricating engineer for the American Oil Co.; from Baltimore, Md., to Washington, D. C. . . . **RUSSELL C. HANSCOM,** motor-check engineer, Tide Water Associated Oil Co.; from San Francisco to Seattle.

W. R. BRASHEAR is doing sales research work for the S. G. Frantz Co.,

W. R. Brashear
Makes Change

New York. He was with MacCarthy Motor Co. in St. Louis. . . . **HARRY E. BLASINGHAM,** who was general purchasing agent, Hercules Motor Corp., Canton, Ohio, has taken a similar position with Schwitzer-Cummins Co., Indianapolis.

Traffic Institute

DR. MILLER McCLINTOCK, director of the Yale University Bureau for Street Traffic Research, served on the administrative committee of the National Institute for Traffic Safety Training held last month at the University of Michigan. . . . **MAXWELL HALSEY,** assistant director of the Yale Bureau, was a director of the technical courses. . . . Opening session speakers included **PAUL G. HOFFMAN,** president of the Automotive Safety Foundation and president of Studebaker Corp., and Dr. McClintock. . . . **B. E. HUTCHINSON,** vice-president and chairman of the finance committee, Chrysler Corp., spoke briefly at the opening day luncheon.

WILLIAM L. BATT, president of SKF Industries, Inc., is discussing "Fusing the Interests of Labor, Management and Consumer" at a conference on human relations being held at Silver Bay on Lake George, N. Y., Aug. 31 to Sept. 3. . . . Mr. Batt is chairman of the coordinating committee of the Seventh International Management Congress to be held in Washington, D. C., Sept. 19-23. . . . **RALPH E. FLANDERS,** president, Jones & Lamson Machine Co., is chairman of the committee on production. . . . Other SAE members serving on the Congress Council are **CHARLES F. KETTERING, PAUL W. LITCHFIELD, JAMES D. MOONEY** and **ALFRED P. SLOAN, JR.** . . . Mr. Flanders will speak before the Congress on "The Balancing of Incentive and Security."

ANDY HALFORD, for 8 years superintendent of the Adcox Schools at Portland, Ore., has purchased an interest in Bankhead & Walters, Portland, Ore., a firm specializing in brake and wheel alignment work. He will install and supervise a modern tune-up and electrical department in connection with the company's other services.

M. P. BAKER, formerly chief draftsman Waco Aircraft Co., Troy, Ohio, is located in Burbank, California, as senior engineer of the Lockheed Aircraft Corp. . . . **EMERY B. KEREKES** has joined Boller Motors Corp., Curtiss-Wright Airport, Baltimore, Md., as engineer.

Award Committee

D. P. BARNARD, assistant director of research, Standard Oil Co. (Ind.), has been elected chairman of the Harry L. Horning Memorial Award Committee. He will serve for one year. Also appointed to the committee are **A. L. BEALL,** research engineer, Wright Aeronautical Corp., to serve two years, and **J. B. MACAULEY, JR.,** research engineer, Chrysler Corp., to serve three years.

A. L. VARGHA, who will soon celebrate the silver anniversary of his membership in the SAE, has resigned his position of designing engineer with

A. L. Vargha
A 25-year Member

Adam Opel, A.G., Russelsheim, Germany, and is in Detroit awaiting a new assignment with General Motors. Before joining Opel three years ago Mr. Vargha was in the Chevrolet engineering department for 11 years.

PAUL G. FITZPATRICK, former sales engineer with the Detroit Compensating Axle Corp., in New York, has taken a similar position with the Brockway Pacific Truck Co., Inc., in Los Angeles. Mr. Fitzpatrick, who was a member of the Metropolitan Section Governing Board, motored west, stopping at Yellowstone National Park and other points of interest en route.

CAPT. ARTHUR B. NICHOLSON, Coast Artillery Corps, United States Army, is attending the Air Corps Tactical School at Maxwell Field, Montgomery, Ala. Captain Nicholson was senior coast artillery instructor to the newly organized Philippine Army from March, 1937, until he returned to the United States in July of this year.

Recent Graduates

WILLIAM B. LOVE, who graduated from Purdue University last June, is a draftsman at Studebaker. . . . **STEPHEN E. BELSEY,** another Purdue graduate, will continue his studies as a graduate student at California Institute of Technology. . . . Two 1938 University of Michigan graduates, **DEXTER HORTON** and **SIDNEY B. EHRLICH,** report connections. Mr. Horton is with the Hickory Dairy Co. of Ann Arbor, Mich., and Mr. Dexter is electrical engineer in the radio department of Stackpole Carbon Co., St. Marys, Pa.

FRED W. PARKER, JR., service manager, Timken-Detroit Axle Co., presented a paper on truck rear axles before the Pennsylvania Motor Truck Association at its recent annual meeting at Bedford Springs, Pa.

David M. Averill

David M. Averill, general works manager of the Nash-Kelvinator plants in Racine and Kenosha until ill health forced his retirement last year, died July 17 at the age of 59. He had been an associate member of the SAE since 1916.

Mr. Averill was long associated with the automotive industry, starting with the old Durant-Dort Carriage Co. under C. W. Nash. This company later became the Dort Motor Car Co. and for a number of years Mr. Averill was its vice-president and general manager. In 1924 he joined the Ajax Motors Co. as its vice-president and general manager, serving in this capacity until he joined Nash Motors in 1927. While with the Dort Motor Co., Mr. Averill took a leave of absence to assist in organizing the Chevrolet Motor Co. in 1912-1913.

Thomas A. Aspell

Following a year's illness Thomas A. Aspell, sales executive of the B. F. Goodrich Co., died early last month on the anniversary of his affiliation with that organization in 1904. He was 54 years of age and had been an associate member of the SAE since 1926.

Mr. Aspell represented his company on the Mexican border in 1916 and 1917. While there he designed tire-mounting trailer equipment for the Army expeditionary forces.

After the War he managed the company's truck tire sales in Akron and was later made assistant manager of the manufacturer's sales division. In 1929 he was named general manager of the company's original equipment tire division.

About Authors

(*Continued from page 21*)

dynamics research for that organization. He has been increasingly active in Society work, being the present head of the Membership Committee and chairman of the Detroit Section for the coming year, as well as a participant in the work of several other administrative and technical committees.

● **Pierre Schon** ***(M '19), applied automobile racing experience to newspaper delivery in 1903, using a 90 hp. Mercedes to rush Paris evening papers to the midnight boat at Le Havre for the morning readers in London. Mr. Schon's quick delivery feat attracted attention of Colonel Nelson, owner of the Kansas City*** Star, ***who brought him to this country to set up one of the first motorized newspaper delivery services in the United States. In 1912 Mr. Schon became branch manager for the Mack Co. in Kansas City and two years later started with General Motors Truck Co. as service manager. He was transferred to the sales division in 1916, and during his 24 years with G.M.C. has had various executive responsibilities. He has taken a prominent part in the Society's T. & M. Activity and, in 1930, organized the program of standardizing C. A. chassis dimensions. He attended college at Longuyon,***

France, and served his apprenticeship in the Panhard-Levassor and Renault factories.

● **Arthur F. Underwood** *(M '30) heads mechanical engineering No. 5 at General Motors Research Laboratories, which investigate the problems of bearings, frictional characteristics of surfaces, and the mechanical factors of lubrication. He has been with G.M. Research Laboratories since 1926, first during the summer when a graduate student and assistant in machine design at M.I.T. while earning his S.M. degree, and afterwards on a full-time basis. He first concentrated on valve gear and camshaft problems, and later transferred his interests to investigations into the problems of oil consumption, oil stability, bearing materials and bearing design. He has designed several machines that are widely used in the petroleum and bearing industries for testing these products and has aided in the development of several new bearing materials.*

Ideas in Zinc

Die castings are invariably thought of in terms of mass production, especially in the automotive industry. But there are many fields, including those closely related to the automotive family, in which the economies and advantages of the process are being realized even though production quantities are considerably less.

Take, for example, the fast growing tractor industry. Many of the production problems in this field are similar to those in passenger car manufacturing and, regardless of comparatively low production, the same cures can apply. We find that one of the most progressive manufacturers in the tractor industry—the Allis-Chalmers Manufacturing Company—has taken its cue from the automobile world and adopted zinc alloy die castings for several important details.

One of the new applications is the rocker arm support for the overhead valve mechanism, and the other is an unique oil filter base die casting. The latter is relatively small, but is intricately cored and serves as the base for the novel oil filter, and embodies the oil pressure gauge as well. This adoption of zinc alloy die castings marks a milestone in tractor production practice.

Designers of all heavy duty equipment can profit by this experience. The economies and physical advantages of zinc alloy die castings can be applied to many low production parts through the availability of the high strength, stable Zamak Alloys, based on Horse Head Special Zinc of 99.99+% purity. The New Jersey Zinc Company, 160 Front Street, New York, N. Y. *Idea No. 16*

SAE Papers in Digest

HERE are digests of papers presented at various meetings of the Society.

Some of these papers will be printed in full in the SAE JOURNAL.

Mimeographed copies of *all papers received* will be available, until current supplies are exhausted, at a cost of 25 cents per copy to members; and at 50 cents per copy to non-members, plus 2% sales tax on those delivered in New York City. Orders for mimeographed copies must be accompanied by remittance and should be addressed to Sessions Secretary, Society of Automotive Engineers, 29 West 39th St., New York.

National Production Meeting—Flint, Mich., Dec. 8-10, 1937

Casting and Machining of Ford Cast Steel Pistons—*W. F. Pioch, Ford Motor Co.*

MOLDING systems were developed, in the casting of the piston, which maintain accuracy to within 0.005 in.

The molds have no internal supports, and the flasks and pattern equipment are maintained to working limits as low as ±0.001 in.

Sand is packed in internal pockets by using a simple, yet very effective, mechanical method. This method has not been used previous to this application.

Equipment has to be designed to locate from castings and still maintain limits in thousandths of an inch.

The first turning operation, locating on a cast face, is the key operation on which all following operations must depend.

Turning tools are held to ±0.0001 in. and set in place with indicator gages which are part of the machine set-up. By use of a paraffin cutting oil, at these close limits, tools run as high as 10,000 parts between grinds instead of only 100 when using soda water as a coolant.

Specially designed machines perform operations with much greater production possibilities.

Even with the rigid inspection methods employed, production is so efficient that there is less than 0.8 per cent scrap.

Precision Forging—*L. A. Danse, Cadillac Motor Car Division, General Motors Corp.*

REVIEWING the history of drop forging, this paper points out that production forging, as it is understood today, dates from 1842 when Nasmyth invented the steam hammer.

Modern drop forging owes much to the efforts of three English scientists—Harry Brearly, Leslie Aitchison, and Herbert Massey—who first explained, in papers published in 1921, how the flow of metal in forgings is directly dependent on the law of plastic flow, long known but little understood. From their leadership it has become known that:

The most important characteristic of a good forging is that the flow lines or fibers should be parallel to the tensile stresses and across the shear on bending stresses met with in service and that, theoretically, the flow of metal in a forging should follow the exact surface contour in highly stressed areas and should follow the main form of the forging throughout. There should be no flash or excess metal that flows out at the parting except at unstressed areas.

Synthetic-Resin Enamel Finishes—*J. L. McCloud, Ford Motor Co.* (Paper published in full, pages 131-136, Transactions Section, March 1938 issue.)

Purchasing, Planning, and Scheduling for Multiple-Model Automobiles—*D. A. Wallace, Chrysler Corp.* (Paper published in full, pages 73-76, Transactions Section, February 1938 issue.)

Do We Understand the Grinding Process?—*R. V. Hutchinson, Olds Motor Works Division, General Motors Corp.* (Paper published in full, pages 89-100, Transactions Section, March 1938 issue.)

Peculiar Machining Problems of Automatic Transmissions—*F. C. Pyper, Buick Motor Division, General Motors Corp.*

THE mechanical equipment for producing the self-shifting transmission was selected as follows:

(1) Proved standard machines with latest improvements for turning, milling, cutting, and grinding, of ordinary parts.

(2) Specially designed automatic machines for combined operations on related functional surfaces.

(3) Specially designed equipment mounted on standard machines to provide accurate locating and indexing from finished surfaces to surfaces on which operations are to be formed.

(4) Latest designs of hardening equipment, insuring the utmost in the prevention of distortion.

(5) Air and temperature controlled inspection rooms with the latest design of inspection equipment.

Because of severe restrictions on the size and weight of transmission parts, the design of the automatic transmission contains many parts which have several functions incorporated in each part, and these parts of light section must be endowed with qualities of high wearability. In order that the many functions may be carried out with smooth, uniform action, it is necessary to maintain a high order of accuracy in machining such parts.

Discussion in the paper is confined to those units which presented major problems, namely, the case, the drive-gear front unit, the clutch-drum front unit, the valve body, and the front-carrier-assembly rear unit.

Recent Developments in Spline and Gear Cutting and Finishing—*R. B. Haynes, Spicer Manufacturing Corp.* (Paper published in full, pages 1-3, Transactions Section, January 1938 issue.)

The Economical Mass Production of Accurate Gears—*C. H. Stanard, Buick Motor Division, General Motors Corp.*

BASED on the conviction that the most economical method of making good gears is to fulfill the laws and definitions pertaining to the geometry of gearing, problems of manufacture were resolved into problems of uniformity, accuracy, economy, and quantity. To tell how these problems are solved is the purpose of this paper.

In our first steps we have the close cooperation of the metallurgical and forging departments, the first in specifying and maintaining materials of uniform quality as to analysis and structure, and the second in producing forgings of uniform structure with symmetrical distribution of stock around the pierced hole.

The forging is very important, affecting the economy, uniformity, and final accuracy of the product. With the elimination of drilling, broaches are drawn through the forging, producing the finished size bore in some blanks. Grinding to finish the bore is necessary in the clutch and second-speed gears.

The paper goes on to describe production operations in sequence, taking up broaching, turning, oil grooving and oil-hole drilling, gear-cutting, hardening, inspecting, hobbing, matching, and concluding with the assembly, testing, and final inspection of the completed transmission.

Section Papers

Northern California – Dec. 14, 1937

Constant-Speed Propellers – *W. F. McGinty, Boering School of Aeronautics.*

THE constant-speed propeller enables startling increases in payloads and ranges by allowing aircraft designers to harness more highly supercharged engines to more heavily loaded airplanes and still be able to take off without excessively long runs. Besides very acceptable increases in payloads, there is a gratifying increase in cruising speeds when using constant-speed propellers, with the same power as before. Without the variable-pitch constant-speed propeller, power loading could not be much greater than 15 lb. per rated hp., and wing loadings would be under 15 lb. per sq. ft.; yet today we see wing loadings in excess of 30 lb. per sq. ft. and considerably higher rated power loadings.

The newest development in propellers of the constant-speed type is the Hamilton Standard constant-speed type with a hydro-controlled "override" into full-feathering position. This type of propeller is used on the Douglas DC-4.

Metropolitan – Dec. 15, 1937

Standardization and Research Horizons – *C. W. Spicer, Spicer Manufacturing Corp.*

INDUSTRIAL standards are akin to the hypotheses of the scientist – they define our present state of knowledge and live only so long as they continue to define adequately. In a word, an engineering or industrial standard is a common meeting place for the purchaser, the seller, and the user.

Standardization, starting with comparatively simple applications to obtain interchangeability of parts in a few important items, has grown steadily in volume, scope, and application into the present broad and comprehensive system. This development has taken place entirely because standardization has proved its value in reduced waste, conserved effort, lower cost, improved usage, and simplified service. It is pointed out that mass production and efficient operation would be practically impossible except at much greater costs if we did not have the benefit of these standardization activities.

The paper takes up in detail the growth of standardization, the S.A.E. Handbook, the fields of standardization, classes of standards, scope of standards, standardization procedure, and dividends from standards.

Northern California – Jan. 11, 1938

Engine Bearing Processing and Its Effects – *R. A. Watson, Federal Mogul Corp.*

THE increased burden on the bearings of machines in recent years has forced increased activity in the investigation of bearing materials. These studies, however, have resulted in few changes in the original Babbitt formula until recently.

Developments in the babbitt alloys covered in this paper include the introduction of tin-base babbitt metal for use as a lining between engine base and crankshaft and in connecting-rods. Die-cast bearings; cast-in connecting-rods; centrifugal casting of bearings; and steel-back bearings are other innovations discussed. The die-casting of bearing alloys is said to leave little to be desired. Applications, advantages, and limitations of cadmium and copper-lead alloys are set forth, and consideration is given to their effect upon lubrication.

Canadian – Jan. 19

Economic Benefits to Canadians Resulting from the Operations of the Automotive Manufacturing Industries in Canada – *J. C. Armer, Dominion Forge and Stamping Co., Ltd.*

THE dominant criticism of Canada's National Protective Policy is that, in many instances, it causes the people of Canada to pay more for manufactured articles than they would have to pay if there were no protection afforded their manufacture in Canada. The automotive industries in Canada have been developed as a result of Canada's National Protective Policy. That these industries have an economic advantage to Canada and Canadians far in excess of the additional cost of motor vehicles in Canada resulting from the protection afforded, has been established in fact by the Traffic Board Survey, and its balance sheet showed that this net economic advantage to Canadians amounted to between $43,000,000 and $50,000,000 in 1936.

In a discussion of the factors which constitute these economic advantages, the debits and credits are detailed and compared. In other sections of this paper, the reasons for the industry's ability to make such contributions to employment are discussed; the widespread economic advantages are pointed out; and it is shown that, whereas prices are higher in Canada than in the United States, they are much lower than in many other countries. The paper closes with a dissertation on merchandising cars in Canada, and an explanation of why Canadian imports of cars are increasing.

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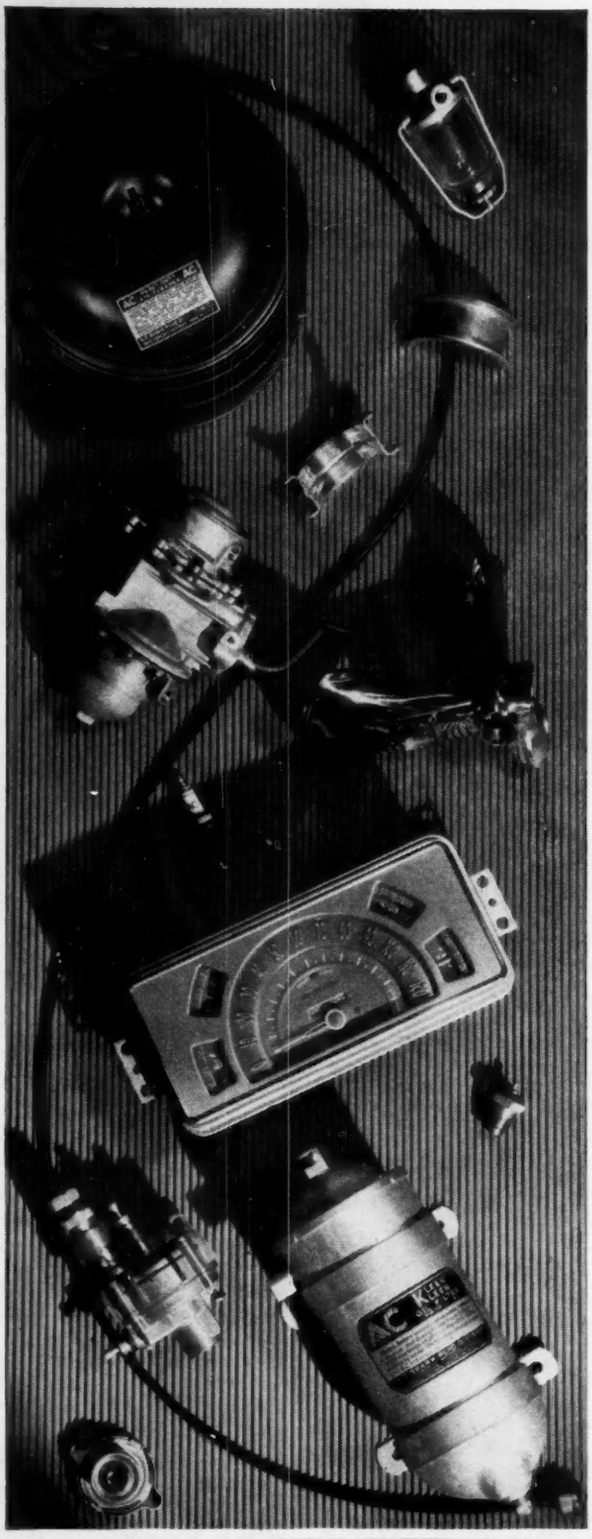

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